

History of Chemistry

Peter Swidersky

timelines



1920



1820

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19	20	21	22	23	24	25	26	27	28	29	30	31			
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
119	120											120	121	122	
123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154
155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186
187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202

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Introduction

The timelines on the history of chemistry should provide a historical overview, which allows a quick orientation in the historical development of the diverse branches of chemistry.

It is not possible to fully depict all of the essential aspects of the history of chemistry on 30 pages. Thus, even 300 pages would not be enough. In order to keep an overview of important events, the tables were limited to 30 pages. At the end of the tables there are two more overviews ***From Ancient to the Modern Age*** and the ***Way to Modern Chemistry***, which show the period from 1700 to 1900 in more detail. According to which criteria were the tables created?

The tables were compiled in terms of different aspects.

Reactions and equations that bear the names of scientists

During the studies, students of chemistry get to know a number of name reactions and equations that bear the names of scientists. The ***Gibbs-Helmholtz*** equation is a very important topic in physical chemistry. In biochemistry, students are confronted with the ***Michaelis-Menten*** kinetics, and without knowing the ***Diels-Alder*** reactions, nobody will pass organic chemistry. These three examples already hold the names of 6 scientists.

Many scientists who stand with their names for important reactions and equations were listed chronologically in the tables, but by no means is the list complete. However, it taken care of that all topics of chemistry are represented in the tables by important discoveries.

Humans who significantly influenced the course of chemical history

Apart from chemists, also mathematicians, physicists and discoveries of humans who significantly influenced the course of chemical history were included.

The invention of ***Gutenberg's*** printing press revolutionized, among other things, the spread of knowledge in chemistry. Serving as example is a method developed by the mathematician ***Euler*** used for numerical simulation in the field of modern chemical reaction engineering. Linear regression according to the method of ***Gauss*** is used for the calculation of calibrations in modern analytical chemistry. Today, computers are used for data recording and evaluation as well as for instrument control, which go back to inventions of ***Zuse***, among others.

E

The chapter on the discovery of elements and the development of the Periodic Table of the Elements is a topic that was included into the overview. Hydrogen is the lightest and most abundant element in the universe, the reaction with atmospheric oxygen leads to an explosion with a big bang. Indeed, the discovery of hydrogen is in a sense also the big bang for modern chemistry. This is why hydrogen appears in the tables. However, more exotic elements were also chosen, because of some interesting and curious stories of the discovery and naming. Not all elements could be presented in the tables.



The modern atom models and theories of chemical bonding essentially originate from the developments of theoretical physicists. This aspect is represented in the time tables as well, because without these valuable works modern chemistry comprising the understanding of the chemical bond and today's periodic system with the arrangements of the electron configurations and quantum numbers would not exist.



Not all inventions were planned and some discoveries are the result of coincidences. The aspect was also taken into account with a few examples.



A complete list of all the Nobel Laureates would already fill the tables completely. However, the fewest inventions, discoveries and developments were awarded a Nobel Prize. Since the first Nobel Prize in Chemistry, given to **Jacobus Hennicus van't Hoff** in 1901, only 5 Nobel Prize in Chemistry were awarded women until 2018.

In view of the limited opportunities that women in science had for research, their achievements are particularly notable. Therefore all five women that received Nobel prizes in chemistry were included in the tables.

Discoveries, syntheses and procedures for chemical products

Soda, **sulfuric acid**, **ammonia**, and **chlorine** are four important mainstays of the chemical industry. Developments involving these substances are therefore highlighted in color in the table.

In 1750 **soda** was already a much sought-after product, which was needed for bleaching processes and was used for washing, tanning, dyeing and printing on textiles. The soap makers used soda to make soap, and the glassmakers were unable to melt glass without soda.

The production volumes of **sulfuric acid** were regarded as an indicator of the performance of a country's chemical engineering. Sulfuric acid is used in many processes, it is one of the most produced chemicals in the world and is therefore also called the blood of chemistry.

Ammonia is the prime example of so-called dual use. It is still used today as a starting material for the production of fertilizers and explosives. The Haber Bosch process enabled the feeding of large parts of the world's population. At the same time, the process made possible the use of enormous amounts of ammunition. With a production of more than 100 million tons per year, ammonia is one of the most synthesized substances on earth. About 1.4% of the total global energy consumption is attributable to the Haber-Bosch process.

Chlorine is also one of the most important basic products of the chemical industry. Most of the chlorine is used to synthesize vinyl chloride and polyvinyl chloride. Chlorine is also used to produce many other organic compounds such as chlorinated hydrocarbons and chloroaromatics-, as well as many inorganic compounds.

Epochs in the history of chemistry

Many of important basics for modern chemistry were laid long time ago before any Nobel Prizes were awarded.

Already in the epochs of prehistory, antiquity, the Middle Ages, the Renaissance and the Enlightenment, the foundations for modern chemistry were laid, and the period between 1650 and 1850 represents the exciting epoch of the transformation from alchemy to modern chemistry, especially in France, England and Germany.

The epochs of the history of chemistry are similar to the well-known historical epochs, but somewhat extended or displaced. Of course, the sequence between epochs is fluent and the delimitation between the historical sections may be controversial, as the state of knowledge in different countries and continents were never identical.

Therefore, overlaps of epochs are the consequence. The inventions, discoveries and developments in the tables are presented chronologically. The epochs early history, ancient, the Middle Ages, Renaissance, and "the birth of chemistry" as well as the chemistry in the modern age are marked in the tables with different colors.

Major subjects of chemistry

With the time tables on the history of chemistry it is possible to move on the basis of subject areas in a time travel through the history of chemistry.

An overview of these topics is given in the table before the timelines. In addition to the topics already described (*elements, atom models, Nobel Prizes*), other topics such as historical aspects concerning the major companies *Bayer and BASF* as well as the development of databases were included in the tables. It is possible to move forward in those subject areas in a time travel through the tables by mouse click.

The major subsections of chemistry, *inorganic chemistry, organic chemistry / natural products, biochemistry/biotechnology, physical chemistry, analytical chemistry* and *chemistry of polymers* are added to the tables with their own symbols.

It is also possible to move through the tables in chronological order only with regard to these major subsections. After the last historical event on a topic, you can return to the theme table with another mouse click. You can always move according to the topics on time travel by clicking the corresponding blue shortcuts (not the symbols).

References are indicated in the tables as numbers found in square brackets. Behind the timelines, the given literature is listed in the appendix.

Peter Svidersky, 07.04.2021

EXPLANATIONS OF THE SYMBOLS AND COLORS IN THE TIME PANELS

Clicking on the shortcuts will take you to a time-related journey through the tables

 E	Chemical Element Discoveries	 CAS	Chemical Abstracts Service, SciFinder, Databases, Societies, Institutes, Education and Conferences
 PSE	Periodic Table of Elements, Designations, Developments	 IC	Inorganic Chemistry
 AM	Atomic Models and Chemical Bonding	 OC	Organic Chemistry Natural Products
 ZU	From Pure Coincidences to Significant Discoveries	 BC	Biochemistry Biotechnology
 NO	Nobel Prizes, Discoveries, Nominations and Award Ceremonies	 PC	Physical Chemistry
 BAY	History and Developments at Bayer	 AN	Analytical Chemistry
 BASF	History and Developments at BASF	 PO	Chemistry of Polymers

Temporal Epochs

Prehistory and Early History	1,5 million BC – 330 B.C.	Epoch	
Ancient	800 BC - 600	Epoch	
Middle Ages	600 - 1400	Epoch	
Renaissance	1400 - 1650	Epoch	
“Birth of Chemistry as a Science“	1650-1850	Epoch	
Chemistry of the Modern Age	1850->	Epoch	

Discoveries, Syntheses and Procedures of World Products

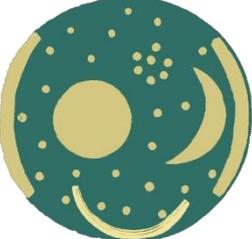
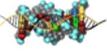
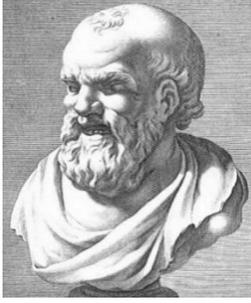
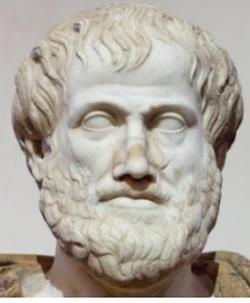
Soda	Na_2CO_3	Na₂CO₃	
Sulfuric Acid	H_2SO_4	H₂SO₄	
Ammonia	NH_3	NH₃	
Chlorine	Cl_2	Cl₂	

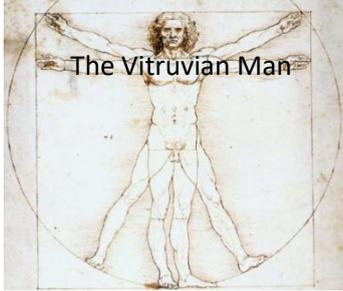
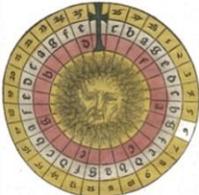
2018

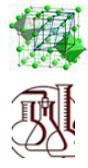
HISTORY OF CHEMISTRY

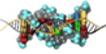
TIMELINES **Applied Chemistry**

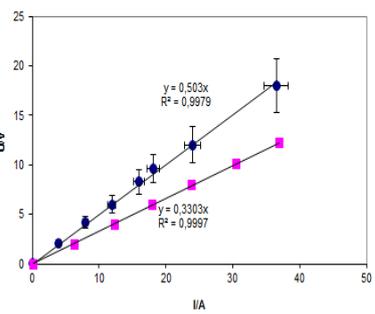
Epoch	1,5 million B.C.	
discovery of fire by mankind		
Epoch	40.000 BC - 30.000 BC ->	
cave painting		
Epoch	20.000 BC – 2.000 BC (End of the Neolithic Age)	
 E	<ul style="list-style-type: none"> • Friction fire lighting • Pottery • Cooking and thickening • Drying • Conserving • Grease and sebum recovery • Operation with oil lamps • Known elements: Au, Ag, Cu, Fe (meteorites) 	

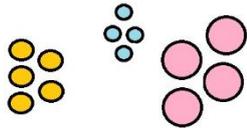
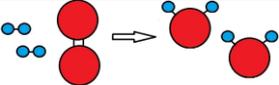
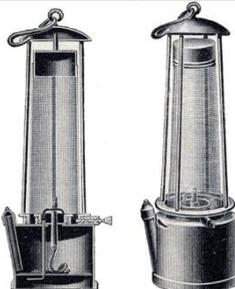
Epoch		1900 BC – 650 BC (Bronze Age)	
 E IC		<ul style="list-style-type: none"> • Bronze production (Sn + Cu) • Oxidation of sulphide ores • Charcoal production • Carbon as a reducing agent • Lime burning • Production of glass 	
			
Epoch		1000 BC Chr. – 330 BC (Iron Age)	
 E BC IC OC		<ul style="list-style-type: none"> • Alcoholic fermentation  • Leather tannery • Production of Iron • Mercury recovery / Amalgam production  • Fat saponification • Glue production  • Manufacture of paints • Turpentine oil distillation • Salt production 	
			
Epoch		800 BC – 600 (Ancient)	
 AM  E	 	<p>Theories of the transformation of substances</p> <p>460-371 BC: Demokrit (picture left): Atom => indivisible smallest elementary particle</p> <p>384 BC – 322 BC: Aristoteles (picture right): Element theory</p> <p>100: Maria Writings on alchemy in Egypt</p>	
		<p>[1] [3]</p>	
287-212 BC	Archimedes von Syrakus	Basics for the development of mechanics, Lever Law, Archimedean Principle , inventions and combination of various machine elements	
Epoch		600 - 1400 (Middle Ages)	
800		Book of Kells : Written in Scotland and brought to Ireland	
900 IC		Development of "Chinese gunpowder" in China 	
about 1150	Theophilus Presbyter		Book Schedula Diversarum Artium : Art and craft techniques, alchemical recipes
1200-1280	Albertus Magnus	Pioneer of Christian Aristotelianism	
1220 - 1292	Roger Bacon		Book Opus Majus : Formulations about sulfuric acid, "separating water" and black powder

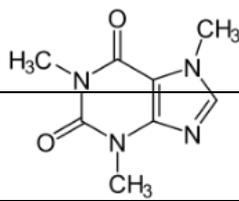
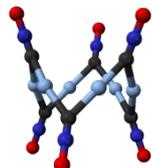
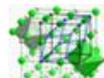
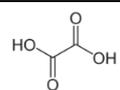
Epoch	600 - 1400 (Middle Ages)	
1235 - 1311	Arnaldus von Villanova	 Collection of 20 alchemical writings banned by the Inquisition
1235-1315	Raimundus Lullus	 More than 280 writings (logic, theology, philosophy)
Epoch	1400 - 1650 (Renaissance)	
1413	Ulmannus	 Book of the Holy Trinity (many recipes and devices)
1400 – 1468	Johannes Gensfleisch (Gutenberg)	 Invention of printing
1452 - 1519	Leonardo da Vinci 	 Anatomical studies Ideas and inventions: Aircraft Diving suits Weapons machines
1493 – 1541	Paracelsus Alchemist Astrologer Physician	<i>All things are poison, and nothing is without poison; only the dose causes a thing not to be a poison</i>
1531-1596	Thurneysser Mineralogist Alchemist Wonder healer astrologer	 The book " Archidoxa " in the form of an astrolabe with planetary charts for predicting the personal future and natural events.
1540 OC	Valerius Cordus	Valerius Cordus synthesizes diethyl ether from ethyl alcohol and sulfuric acid
1545 – 1591	Marco Bragadino	 Alchemical tricks – impostor , executed for alchemical fraud
1614	John Napier	Publication of the first logarithmic chart
1654	Robert Bissaker	Slide rule with movable read between two scales
1626-1691 AN	Robert Boyle	Detection of iron salts and copper salts in water by using gall apple juice 
1636-1686	Freiherr von Krohnemann	 Ennobled because of alchemical merits, executed for alchemical fraud

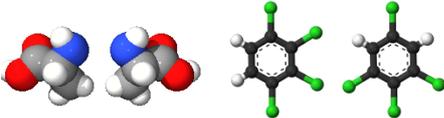
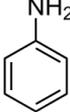
Epoch	1650 – 1850	Birth of Chemistry as a Science			
1663-1727	Doktor Eisenbarth	National fame as a surgeon, cataract surgeon, Team of quacks of about 180 employees: Assistants, dealers, wizards, acrobats, fire-eaters, bands and theatre groups			
1670-1709	Graf von Ruggiero	Alchemical impostor, executed for alchemical fraud			
1600-1800	Johann Rudolph Glauber [1] [3]	Isaac Newton [1]	Johann Friedrich Böttger [3]	Carl Wilhelm Scheele [1]	Antoine Laurent de Lavoisier [1] [3]
					
	1604-1670 Pharmacist Alchemist	1643-1727 Physicist Alchemist	1682-1719 Alchemist Inventor	1742-1786 Pharmacist	1743-1794 Lawyer Private scholar
1655 IC OC	Glauber		Foundation of the first chemical production company in Amsterdam		
1668	Newton	Development of the first reflecting telescope (1668-1672)			
E E 1669	Hennig Brand [3]	P Synthesis of white phosphorus from urine			
1687	Newton	Book <i>Philosophiae naturalis principia mathematica</i>			
		<ul style="list-style-type: none"> • Publication of the Gravitational Laws • Foundation of classical mechanics 			
1709 IC	Böttger	Invention of porcelain in collaboration with Ehrenfried Walther von Tschirnhaus			
1710	Böttger		Technical management of the first porcelain manufactory		
E E 1735	Georg Brandt	Co Preparation and characterization of cobalt			
H₂SO₄ 1746 IC	John Roebuck [3]	First lead chamber process for the production of sulfuric acid			
1750 AN	Gabriel Francois Venel	Use of the color indicator violet juice in a mineral water analysis and observation of the red coloration when adding sulfuric acid.			
E E 1751	Frederic von Cronstedt	Ni Preparation and characterization of nickel			

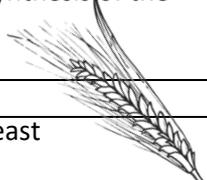
Epoch	1650 – 1850	Birth of Chemistry as a Science	
E 1766	Cavendish [1] [3]	H₂	Dissolution of metals in acids, formation of hydrogen (combustible air)
1768	Leonhard Euler	Euler Method in the book <i>Institutiones Calculi Integralis</i>	
1769 OC	Scheele	 $\begin{array}{c} \text{COOH} \\ \\ \text{H} - \text{C} - \text{OH} \\ \\ \text{HO} - \text{C} - \text{H} \\ \\ \text{COOH} \end{array}$	Discovery of tartratic acid as first organic acid 
E 1770	Johann Gottlieb Gahn	P	Discovery of phosphorus in bone ash
NH₃ 1771 IC	Scheele	Discovery of ammonia, hydrogen sulfide and hydrofluoric acid 	
E 1772	Scheele	O₂	Obtaining oxygen from calcium nitrate and sulfuric acid
1772 PC	Lavoisier	Law of Mass Conservation / Air is a gas mixture 	
E 1772	D. Rutherford Cavendish 1731-1810 Scientists Scheele	N₂	Discovery of an air constituent that does not sustain combustion (nitrogen)
Cl₂	Scheele	Cl₂ Synthesis of Chlorine from hydrochloric acid and manganese	
E 1774	Scheele	Discovery of arsenic, preparation of white phosphorus from bone ash	
1775 BC	Lavoisier	Indispensability of Oxygen for combustion and respiration 	
1780 OC	Scheele	Discovery of lactic acid	$\text{H}_3\text{C}-\underset{\text{OH}}{\text{CH}}-\text{COOH}$ 
1781 IC	Cavendish	Synthesis of artificial water-> Lavoisier 	
1783 OC	Scheele	Isolation of glycerine from olive oil Isolation of hydrogen cyanide from Berlin Blue	$\text{O}-\text{CH}_2-\underset{\text{OH}}{\text{CH}}-\text{CH}_2-\text{OH}$ 
1784 OC	Scheele		Discovery of citric acid 
1785 OC	Scheele		Discovery of malic acid 
1786 OC	Scheele	Discovery of gallic acid	$\text{HO}-\text{C}_6\text{H}_2(\text{OH})_2-\text{COOH}$ 
1785 1787	Lavoisier	Refutation of Phlogistontheory First systematic nomenclature of chemistry	

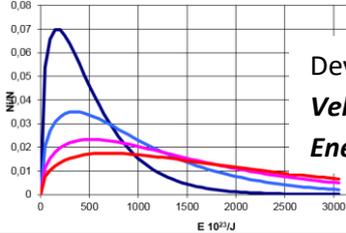
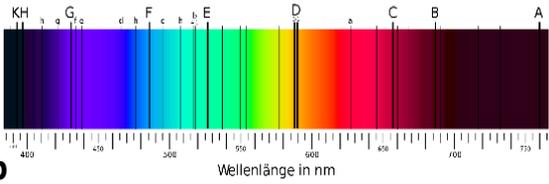
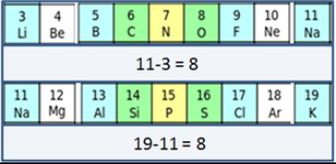
Epoch	1650 – 1850 Birth of Chemistry as a Science	
1740 – 1850	Nicolas Leblanc [3]	Martin Heinrich Klaproth [1][3] Alexander von Humboldt
		 1743-1817 Pharmacist
		 1769-1859 Natural Scientist
		Gay Lussac [1] [3]
		 1778 - 1850 Chemist and und Physicist
		 1778 - 1850 Natural Scientist / Teacher
Na_2CO_3	Leblanc	Production of artificial soda, the first large-scale manufacturing process in chemistry 
1789 IC	Klaproth	U Zr Discovery of the elements uranium and zirconium
 1789	Klaproth	Ti Discovery of the element titanium in rutile
1792	Carl Friedrich Gauß	Development of the method of the small Squares (regression calculation) 
1895	Klaproth Vauquelin	Cr Discovery of the element chrome
 1797	Klaproth	Te Discovery of the element tellurium
 1798	Cavendish	Determination of the density of the earth
1798	Alexander von Humboldt	<i>American Research Trip</i>  
1799-1804		

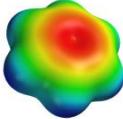
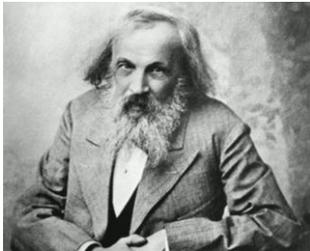
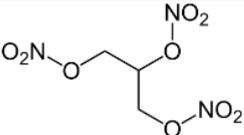
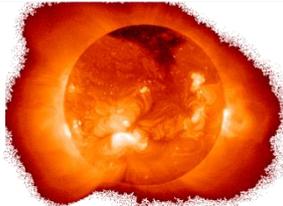
Epoch	1650 – 1850	Birth of Chemistry as a Science	
1799 CAS		Foundation of the <i>Royal Institution of Great Britain</i>	
1800 PC	Volta	Construction of the <i>Volta column</i> (first battery)	
1801 PC	Dalton	Formulation of the partial pressure law $p = p_1 + p_2 + \dots$ $p_1 = y_1 \cdot p$	
 1801	Gustaf Ekeberg	Ta	Discovery of tantalum as an element
 1801	Charles Hatchett	Nb	Discovery of niobium in a sample of columbite ore. The element was first called columbium.
1802 PC	Gay-Lussac [1] [3]	<i>Law on Thermal Expansion of Gases</i>	
1770-1870	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Sir Humphry Davy [3]</p>  <p>1778-1829 Chemist</p> </div> <div style="text-align: center;"> <p>Jöns Jakob Berzelius [1] [2][3]</p>  <p>1779-1848 Physician/Chemist</p> </div> <div style="text-align: center;"> <p>Michael Faraday [1] [3]</p>  <p>1791-1867 Chemist</p> </div> </div>		
 1803	Berzelius	Ce	Discovery of cerium (with Klaproth and Hisinger)
1803 PC	Berzelius	Electrolysis for the recovery of pure metals	
AM  1803	Dalton		Chemical atomic theory
1804	Dalton		<i>Law of Multiple Proportions</i>
 1807	Davy	Na K	Synthesis of sodium and potassium via melt electrolysis
1808 PC	Gay Lussac	<i>Law of Multiple Volumes for Gases</i>	
 1811	Bernard Courtois	I₂ Discovery of iodine	
1811 PC	Amedeo Avogadro [3]	<i>Avogadro's Law</i> on the number of particles in gas containers	
1815 PC	Davy	Invention of firedamp miner's lamp	

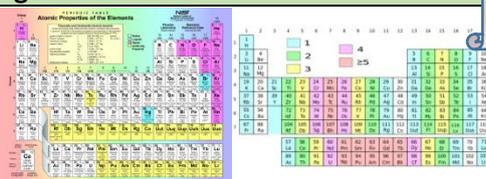
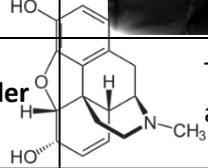
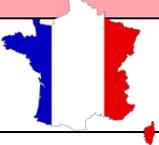
Epoch	1650 – 1850	Birth of Chemistry as a Science	
PSE  1815	Berzelius	Symbolic abbreviation for chemical elements	
E 1817	Johan August Arfwedson [1] Chemist	Li	Discovery of the element lithium
E 1818	Berzelius	Se	Discovery of the element
PSE  1818	Berzelius	First atomic weight table	
1819 OC	Runge 1795-1867 Chemist	Isolation of caffeine from coffee beans	 
1823 OC	<u>Chevreul</u> 1786-1889 Chemist [1]		Founder of fat chemistry and the modern theory of colors <i>Recherches chimiques sur les corps gras d'origine animale</i> [4]  
Cl₂ E 1823 E	Faraday	Verflüssigung von Chlor	
1823 Justus von Liebig [2] [3] 1803-1873 Chemist IC		 Silver fulminate Silver cyanate AgOCN Friedrich Wöhler (1800-1882) Physician / Chemist [2] [3]	Liebig and Wöhler made the observation that two different substances can have the same gross formula (isomerism).  
1823 PC IC	Döbereiner		Invention of a lighter in which hydrogen ignites on platinum black, it is the first example of catalysis  
Na₂CO₃ 1823 IC	James Muspratt	First soda production in Liverpool according to the Leblanc - process 	
1824 OC IC	Wöhler	Recovery of oxalic acid from cyanogen	  
E 1824	Berzelius	Si	Discovery of the element silicon (in a pebble)
1825 OC	Faraday		Isolation of benzene from coking gas 

Epoch	1650 – 1850	Birth of Chemistry as a Science	
E 1826	Antoine Jerome Balard 1802-1876 Chemist [1]	Br	  Preparation of the element bromine from seaweed
E 1827	Wöhler	Preparation of aluminum from alumina	
E 1828	Wöhler	Be Y	Isolation of beryllium and yttrium
1828 OC	Wöhler	Synthesis of urea, end of the theory of the " <i>vis vitalis</i> " -> justification of organic chemistry	
E 1829	Berzelius	Th	 Berzelius publishes the discovery of the element thorium
E 1829	Wöhler	P	Synthesis of phosphorus from bone ash
PSE  1829	Wolfgang Döbereiner	<i>Rule of the Triads</i> - The foundation for the periodic table of the elements	
1830 OC	Berzelius	Coinage of the term "isomerism"  	
1831 AN	Liebig	<i>Five-Ball Potash Apparatus</i> designed to improve elemental analysis 	
H₂SO₄ 1831 IC	Peregrine Phillips [3]	Development and patenting of the contact process to oxidize sulfur dioxide spontaneously to sulfur trioxide (Pt as catalyst, at this stage no industrial conversion) 	
1832 OC	Liebig / Wöhler	The joint publication of a work on the benzoyl radical is considered the beginning of radical theory  	
1833 PC	Faraday	Coinage of the terms cathode, cation, anode, anion emergence of <i>Faraday's law</i> 	
ZU  1834 OC	Friedlieb Ferdinand Runge	Isolation of aniline from coal tar -> Foundation of color chemistry  	
1835 IC	Liebig		Process for manufacturing silver mirrors 
1835	Berzelius	Coinage of the term "catalytic force"	

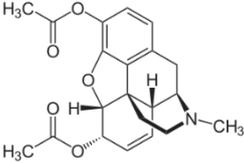
Epoch		1650 – 1850 Birth of Chemistry as a Science	
<p>Heinrich Rose Mineralogist and Analytical Chemist Christian Friedrich Schönbein German-Swiss Chemist and Physicist Julius Robert Mayer Physician and Physicist</p>		 <p>Rose 1795-1864 Schönbein [3] 1799-1868 Mayer 1814-1878</p>	
1839 CAS	Liebig	Foundation of the practice-oriented training of chemists in Gießen	CAS
1839 ZU PO	Charles Goodyear [3]	Discovery of vulcanization of rubber	
1840 OC	Liebig	Publication: <i>Die Organische Chemie in ihrer Anwendung auf Agrikultur und Physiologie</i>	
1841 AN	Franz Varrentrapp Heinrich Will	Improvement of Liebig's Potash Apparatus Determination of nitrogen as ammonia	
1842 PC	Julius Robert von Mayer	Paper published on the conversion of mechanical energy into heat in <i>Liebigs Annalen der Chemie und Pharmazie</i> , birth of the <i>First Law of Thermodynamics</i>	
1844 IC	Heinrich Rose	Niobium acid and tantallic acid are different substances	
1844 PC	Petrus Jacobus Kipp	Publication of the invention of <i>Kipp's Apparatus</i>	
ZU 1845 OC	Schönbein	Discovery of the guncotton (nitrocellulose)	
E 1848	Anton Schrötter	P  Synthesis of red phosphorus	
Epoch 1850 → Chemistry of the Modern Age			
1850	Amédée Mannheim	 Uniform slide rule with transparent slider	
1850 OC	Adolph Strecker [2]	Publication of the <i>Strecker Amino Acid Synthesis</i>	
1853 OC	Stanislao Cannizzaro [3]	Publication in <i>Liebigs Annalen der Pharmazie</i> : Synthesis of the first aromatic alcohol (<i>Cannizzaro Reaction</i>)	
1853	Liebig	Invention of meat extract	
1855	Liebig	<i>Law of the Minimum</i> , according to the law the least available fertilizer determines the crop yield	
1855 OC	Alexander Parkes	Patent for the production of artificial horn manufactured from shooting cotton and camphor (<i>Celluloid</i>)	
1859 OC	A. Kekule E. Erlenmeyer	Beginning of structural chemistry	

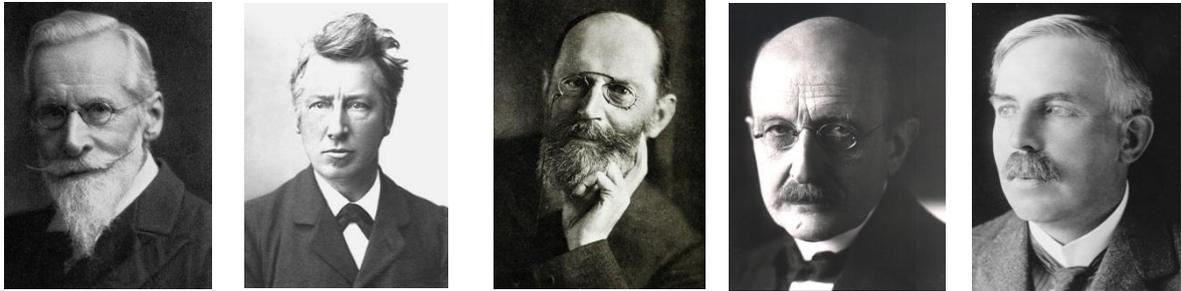
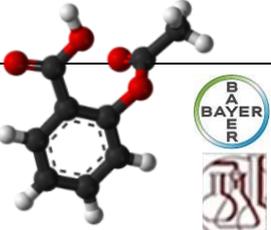
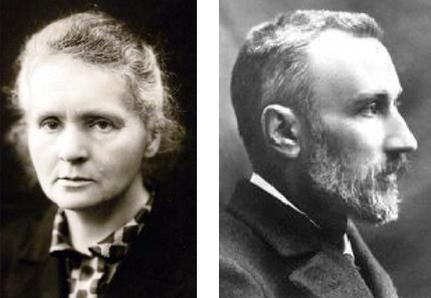
Epoch		1850 → Chemistry of the Modern Age	
			
<p>Robert Wilhelm Bunsen [1] 1811-1899 Chemist</p>		<p>Friedrich August Kekulé [3] 1829-1896 Chemist</p>	
<p>James Clerk Maxwell [3] 1831-1879 Physicist</p>		<p>Ludwig Eduard Boltzmann [3] 1844-1906 Physicist</p>	
1860 PC	James Clerk Maxwell Ludwig Boltzmann	 <p>Development of the Maxwell-Boltzmann <i>Velocity Distribution</i>- and <i>Energy Distribution Function</i></p>	
1860 CAS	Kekulé	<p>Initiative for the <i>First International Congress of Chemists</i> with 140 participants in Karlsruhe</p> 	
1860 OC	<p>Chemical structural formulas of substances can be determined by mental combination of the elemental composition</p> 		
E 1860 1861 AN	Gustav Robert Kirchhoff Robert Wilhelm Bunsen	<p>Development of spectral analysis Discovery of cesium and rubidium Cs Rb</p>  	
1862 IC OC	Wöhler	<p>Synthesis of Calcium carbide from calcium and carbon → Discovery of acetylene</p>   	
1863 AN	Johan Kjeldahl	<p>Development of a method for quantitative determination of nitrogen</p> 	
1863 BAY	<p>Foundation of the company Friedrich Bayer et.</p> 		
1864 OC	<p>Guncotton dissolved in ether / ethanol (1: 2) (collodion) as a wound dressing In the Crimean War collodion served as wound covering</p>		
PSE  1864	John Alexander Reina Newlands [3] Chemist	 <p>At an interval of 8 elements, striking similarities in the properties occur → <i>Law of Octaves</i></p>	

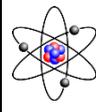
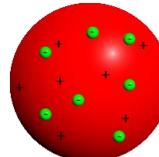
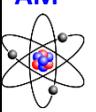
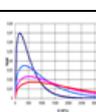
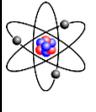
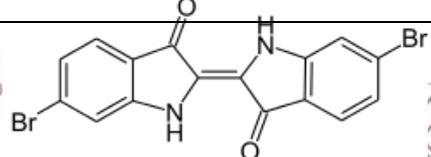
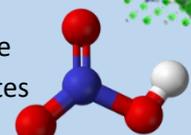
Epoch	1850 → Chemistry of the Modern Age		
1864 PC	C.M. Guldberg Peter Waage Chemists	Publication of the <i>Mass Action Law</i> [1]	
1865 OC	Kekulé 	Publication of a proposal on the structure of the benzene ring, basis for the derivation of the structures of aromatic compounds from coal tar	
Na₂CO₃	Establishment of the Solvay process for the production of soda		
1865 IC	Founding of the Badische Anilin and Soda Fabrik		BASF
	Johann Wilhelm Hittorf [1] 1824-1914 Chemist 	Alfred Nobel [3] 1833-1896 Chemist 	Dmitri Iwanowitsch Mendelejew [3] 1834-1907 Chemist 
			Henri Moissan [3] 1852-1907 Chemist 
1865 PC	Josef Loschmidt 1821-1895	Determination of the number of molecules in one cubic metre of gas <i>Loschmidt Number</i> $L=2,687 \cdot 10^{25} m^{-3}$	
E 1865	Johann Wilhelm Hittorf	P Crystallization of purple phosphorus	
1867 OC	Nobel	The product Dynamite is patented	 
1867 CAS	Founding of the <i>Deutsche Chemische Gesellschaft</i>		CAS
E 1868	Jules Janssen 1824-1907	He Discovery of the spectral line 587.49 nm indicated a new element [3]	
E 1868	Joseph N. Lockyer 1836-1920 Sir Edward Frankland 1825-1899	He  Confirmation of the spectral line of 587.49 nm. Helium was proposed as the name for the new element	
1869 OC	John Wesley Hyatt 1837-1920		Improvement of thermoplastic celluloid for the production of billiard balls in America. The ivory for billiard balls could be replaced. Despite this development, the elephant population continued to decline dramatically. 

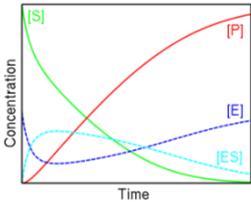
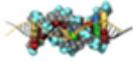
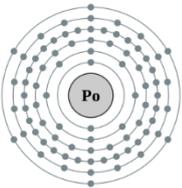
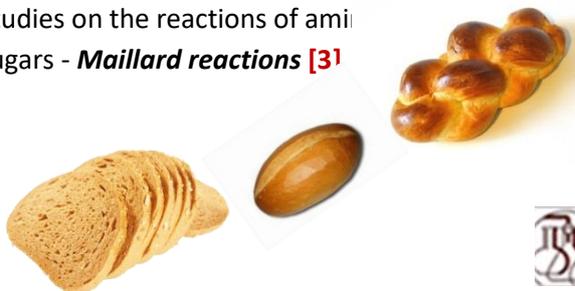
Epoch	1850 → Chemistry of the Modern Age	
PSE  1869	Mendelejew Lothar Meyer	Discovery of the periodicity of the elements [1] 
1869 OC	Heinrich Caro Carl Graebe C. Liebermann	Synthesis of the first natural dye - alizarin 
PSE  1869	Mendelejew	Sc Prediction of the element Eka-boron with the atomic number 21
PSE  1871	Mendelejew	Ga Ge Prediction of the elements Eka aluminum with the atomic number 31 (gallium) and Eka silicon with the atomic number 32 (germanium)
1871 PC	James Clerk Maxwell	 Publication of the thought experiment <i>Maxwell's Demon</i> 
1873 PC	Johannes Diderik Van der Waals 1837-1923 Physiker	 Development of <i>van der Waals - Equation of State</i> [1] (1910 Nobel Prize awarded in physics) $R \cdot T = \left(p + \frac{a}{V_m^2} \right) \cdot (V_m - b)$ 
1874 OC	Charles Romley Alder Wright	 The structure elucidation of various alkaloids and terpenes allowed the constitution of morphine to be elucidated 
H₂SO₄ 1875 IC	Industrial contact process with platinum as a catalyst for sulfuric acid production 	
E E 1875	Paul-Émile Lecoq de Boisbaudran	Ga Production of elementary gallium <i>Patriotic Element</i> 
1876	O.N. Witt	Theory of auxochromic and chromophore groups
1876	Nobel	Production of blasting gelatine with glycerine nitrate and collodion wool
1876-1878 PC	Josiah Willard Gibbs	Series of articles entitled <i>On the Equilibrium of Heterogenous Substances</i> , considered to be one of the greatest achievements in nineteenth-century physics and the basis of physical chemistry -> <i>Gibbs Helmholtz Equation</i> $\Delta G = \Delta H - T \cdot \Delta S$ 
1877 PC	Ludwig Eduard Boltzmann	Work on the relationship between the second law of mechanical heat theory and the theory of probability $S = k_B \cdot \ln(\omega)$ <i>Boltzmann's Entropy Equation</i> 
E E 1879	Lars Fredrik Nilson	Sc Discovery of the element scandium <i>Patriotic Element</i> 
E E 1882	Luigi Palmieri	He Detection of helium on Earth [3] by spectral analysis of Vesuvius lava 

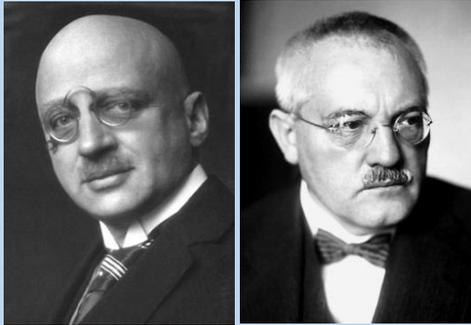
Epoche		1850 → Chemistry of the Modern Age		
	<p>Hermann von Helmholtz [3] 1821-1894 Physiologist / Physicist</p> 	<p>Josiah Willard Gibbs [3] 1839-1903 Physicist</p> 	<p>Svante August Arrhenius [1] [3] 1859-1927 Physicist/Chemist</p> 	<p>Agnes Pockels 1862-1935 Physical Chemist</p> 
1882 PC	Agnes Pockels 1862-1935	Invention of a sliding channel for the examination of surfaces (1932 honorary doctorate from the University of Braunschweig)		
1882 1883 PC	Helmholtz	<p>Three Essays on <i>Thermodynamics of Chemical Processes</i> Application of the laws of thermodynamics to electrochemistry Introduction of the term of <i>Free Energy</i> -> <i>Gibbs Helmholtz Equation</i> $\Delta G = \Delta H - T \cdot \Delta S$</p> 		
1883 CAS	Hans Heinrich Landolt 1831-1910 Chemiker	 	<p>Physico-chemical tables Landolt-Börnstein, single-volume manual of 280 pages</p>	CAS
1885 PC	Henry Le Chatelier	<p><i>Law of Reaction</i>, governing the effect of pressure and temperature on equilibrium [3]</p> 		
E E 1886	Clemens Winkler	<p>Ge Discovery of the element germanium <i>Patriotic Element</i></p>		
1886 IC	Hans Heinrich Landolt	<p>Extensive experiments on iodine formation via the time reaction (<i>Landolt Reaction</i>)</p>		
E E 1886	Henry Moissan	<p>F Preparation of the element fluorine (1906 Nobel Prize in Chemistry)</p>		
1889 PC	Walther Nernst [1] 1864-1941 Chemiker Physiker		<p><i>Nernst-Equation</i></p> $E = E^\circ + \frac{R \cdot T}{z \cdot F} \ln \left(\frac{[Ox]}{[Red]} \right)$ 	
1889 PC	Svante Arrhenius	<p>Temperature dependence of the reaction rate <i>Arrhenius-Equation</i> $k = k_0 \cdot \exp \left(\frac{-Ea}{R \cdot T} \right)$</p>		

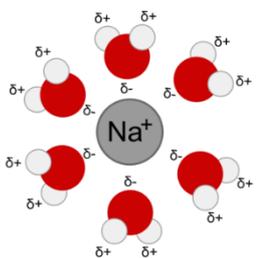
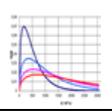
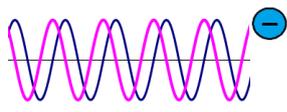
Epoch	1850 → Chemistry of the Modern Age	
1891 PC	Nernst	Nernst's Distribution Law $K = \frac{c(E)}{c(R)} = \frac{n(E) \cdot V(R)}{n(R) \cdot V(E)}$
1892 IC OC	Thomas Willson	Invention of an economic method for the production of calcium carbide  
1893 BAY OC	Felix Hoffmann [2] Chemist and Pharmacist	Preparation of diacetylmorphine (Heroin) from morphine with acetic anhydride carried out by Bayer   
1894 PC	Wilhelm Ostwald 1853-1932 Chemist / Philosopher	 Introduction of the term mole for the amount of substance [3] (1909 Nobel Prize awarded in chemistry for work on catalysis) 
1894	Carbide lamps are used on buildings	
 1895	Sir William Ramsay	He Isolation of helium from a uranium mineral (addition of mineral acids and isolation of the gas) 1904 Nobel Prize awarded in chemistry
ZU  1895	Conrad Röntgen 1845-1923 Physicist	  Discovery of X-ray radiation (first Nobel Prize awarded in physics 1901)
1896 OC	Emil Albert Knoevenagel	Preparation of unsaturated carbonyl compounds (Knoevenagel Reaction) 
1896 BAY	Bayer develops the procedure for the production of diacetylmorphine and allows the new pharmaceutical product to be protected under the brand name Heroin 	
1896	Carbide lamps used on bicycles and other vehicles	
1896 NO	Alfred Nobel	 Publication of the Testament from Alfred Nobel 
AM  1897 AN	Sir Joseph John Thomson [3] Emil Wiechert	Detection of the electron during the investigation of cathode rays and pioneering work for the development of the mass spectrometer (John Thomson, 1906 Nobel Prize awarded in physics)

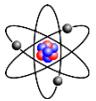
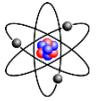
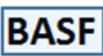
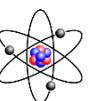
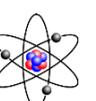
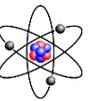
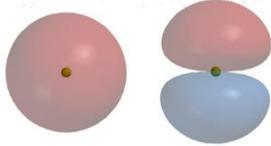
Epoch		1850 → Chemistry of the Modern Age				
William Crookes 1832-1919 Physicist /Chemist	Jacobus Henricus van't Hoff 1852-1911 Chemist	Hermann Emil Fischer [2] [3] 1852-1919 Chemist	Max Planck 1858-1947 Physicist	Ernest Rutherford [3] 1871-1937 Chemist		
AM  1897	Ernest Rutherford	The ionizing radiation of uranium consists of several particles				
1897 BAY OC	Felix Hoffmann [1] [3]	Patent for the production of pure acetylsalicylic acid (<i>Aspirin</i>). The actual inventor may have been Ernst Arthur Eichengrün				
Cl ₂ 1898	Implementation of the electrolytic chlorine production in Ludwigshafen (<i>Chlor-Alkali Electrolysis</i>)					
AM   1898	Marie Curie [3] 1867-1934 Physicist /Chemist Pierre Curie 1859-1906 Physicist				Ra	Isolation of radium from pitchblende
1898 CAS	William Crookes	Speech to <i>the British Association for the Advancement of Science</i> in Bristol. To the year 1918, the demand for fertilizers could no longer be supplied, thus there was a danger of a great famine.				
AM  1900	Max Planck	Discovery of <i>Planck's Constant</i> 1919 Nobel Prize in physics awarded for the year 1918				
1900 BAY	Bayer in Leverkusen					
1901 BC	Jökichi Takamine	Isolation of the hypertensive drug adrenaline [2]				
1901 NO	Röntgen	First Nobel Prize in physics awarded for the discovery of X-rays				
1901 NO	van 't Hoff	First Nobel Prize awarded in chemistry, investigations on the chirality of carbon, reaction kinetics, <i>Avogadro Law for Solutions</i>				

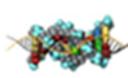
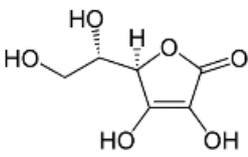
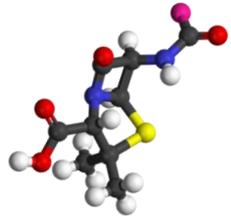
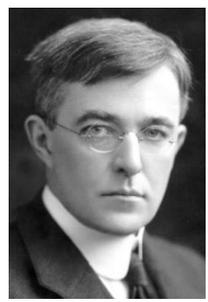
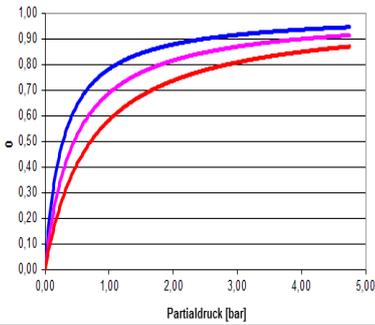
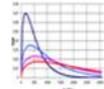
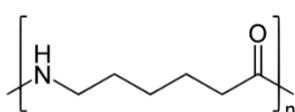
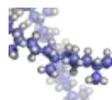
Epoch	1850 → Chemistry of the Modern Age	
1902 BC	Fischer Hofmeister	Hypothesis concerning the structure of the proteins by means of acid amide binding [3] 
1902 OC NO	Fischer	Nobel Prize awarded in chemistry, for the pioneering work on the subject of sugar chemistry (Fischer Projections), Fischer is said to be the founder of organic chemistry [3]  
AM  1903	Joseph John Thomson 1856-1940 Physiker	  First atomic model that attributes an internal structure to the atoms (Raisin Cake Model)
AM  1903 NO	Ernest Rutherford	Radioactive decay can transform chemical elements into those of a smaller atomic number. Classification of radioactive radiation into α -radiation β radiation and γ radiation (1908 Nobel Prize awarded in chemistry) 
1903 PC NO	Arrhenius	1903 Nobel Prize awarded in chemistry for the theory of electrolytic dissociation  
AM  1903 NO	Pierre Curie Marie Curie Antoine Henri Becquerel	Nobel Prize awarded in physics for work on the subject of radioactivity  
1903 OC	6,6'-dibromindigo was synthesized for the first time (purple)   	
NH ₃ 1904 IC PC	Fritz Haber	Work on ammonia synthesis started (1918 Nobel Prize awarded in chemistry)   
1905 PC	Walther Nernst	Formulation of the third law of thermodynamics
1906 NO	John Thomson H. Moissan	Nobel Prize awarded in physics for research on the electrical conductivity of gases / Nobel Prize awarded in chemistry for the preparation of fluorine 
1907 PC	Walther Nernst	Description of diffusion layers (Nernst Diffusion Layer)
1907 CAS	Founding of Chemical Abstracts Service (CAS) 	
1908 NO	Rutherford	Nobel Prize awarded in chemistry, for the examinations on the decay of the elements 
NH ₃ 1908 1909 IC PC NO	Wilhelm Ostwald	Large-scale production of nitric acid by means of oxidation of ammonia (1909 Nobel Prize awarded in chemistry for the work on catalysis, equilibration and reaction rates (Patent awarded to the Ostwald Process 1902)    
1909	Peter Lauritz Sørensen	Invention of the pH scale (pH = potentia Hydrogenii)

Epoch	1850 → Chemistry of the Modern Age	
1909 OC	Paul Friedländer	Determination of the structure of purple as dibromoindigo 
1909	Perrin	The number of particles in 1 mol of substance should be referred to Avoadro Constant $N_A = 6,022 \cdot 10^{23} \text{ mol}^{-1}$
1910 BC	Maud Leonora Menten 1879-1960 Physician Leonor Michaelis 1875-1949 Biochemist/ Physician	Development of the Michaelis-Menten Theory as a mathematical model for the description of enzyme kinetics $E + S \xrightleftharpoons[k_1']{k_1} [ES] \xrightarrow{k_2} P + E$  
AM  1910 AM NO	Robert Andrews Millikan 1868-1953 Physicist	Determination of the elementary charge (1923 Nobel Prize awarded in physics) $e = 1,602 \cdot 10^{-19} \text{C}$  
AM  1911	Ernest Rutherford	Scattering experiments with α -particles on gold foil. The atom is almost empty. The diameter of the atomic nucleus is about 10,000 times smaller than the atom itself -> New Atomic Model
AM   1911 NO	Marie Curie	   Po Nobel Prize awarded in chemistry, for the discovery of polonium 
1911 NO	Heike Kamerlingh Onnes Physicist	Discovery of the phenomenon of superconductivity in mercury (1913 Nobel Prize awarded in physics) 
1912 OC	Louis Camille Maillard 1878-1953 Physician/ Chemist	Studies on the reactions of ami sugars - Maillard reactions [31]  
1912 OC NO	Victor Grignard 1871-1935 Chemist [1]	 $R^1-C(=O)-R^2 + \begin{matrix} \delta^- \\ Br \\ \\ Mg \\ \\ R^3 \\ \delta^- \end{matrix} \longrightarrow \begin{matrix} R^1-O-Mg-Br \\ \\ R^2 \\ \\ R^3 \end{matrix} \longrightarrow \begin{matrix} R^1-O-H \\ \\ R^2 \\ \\ R^3 \end{matrix} + H_2O - MgBrOH$ Nobel Prize awarded in chemistry (Grignard Reaction) [1][3]  

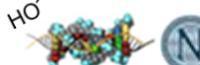
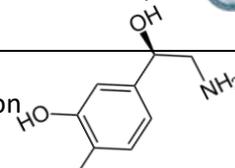
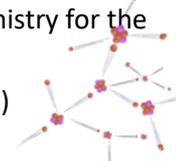
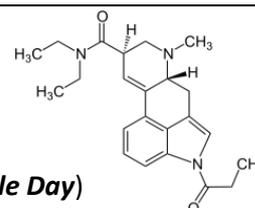
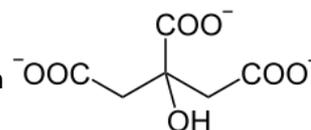
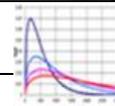
Epoch	1850 → Chemistry of the Modern Age	
<p>AM</p>  <p>1913 [1]</p>	<p>Niels Bohr 1885-1962 Physicist</p>	 <p>Bohr Postulate, Bohr's Model, Quantization of Energy (1922 Nobel Prize awarded in physics)</p> 
<p>PSE</p>  <p>1913</p>	<p>Henry Moseley [1][3] 1887-1915 Physicist</p>	<p>Moseleysches Gesetz</p> <p>Interrelation between the atomic number of an element and the frequencies of characteristic lines of electromagnetic radiation</p>
<p>NH₃</p> <p>1913 BASF NO</p>	<p>Fritz Haber 1868-1934 Chemist</p> <p>Carl Bosch 1874-1940 Chemist Technician</p>	 <p>First plant for ammonia production at BASF </p> <p>Haber-Bosch Process [3]</p> <p>Nobel Prize awarded in Chemistry to Haber in 1918 and to Bosch in 1931  </p>
<p>E</p> <p>1914</p>	<p>Percy Bridgman Physicist</p>	<p>P </p> <p>Discovery of black phosphor</p>
<p>1914</p>	<p>Haber</p>	  <p>Research on the use of poison gas as a weapon in World War I</p>
<p>1914</p>	<p>Nernst-Duisberg-Commission</p>	<p>Commission for the investigation into chemical warfare agents and testing by the German general staff</p>
<p>1914 BASF</p>	<p>Agreement on potassium nitrate production</p>	<p>In close agreement with Carl Duisberg, Emil Fischer and Carl Bosch (BASF) and the High Command agreed on a purchase guarantee and a loan from the Reich of 35 million marks for the construction of ammonia and nitric acid production plants at the end of 1914. </p>
<p>1914 1915</p>	<p>Clara Immerwahr 1870-1915 Chemist</p>	 <p>Clara Immerwahr a chemist and human rights activist fought desperately and hopelessly against the development and use of chemical weapons.</p> <p>Protest against the use of poison gas researched by her husband Haber, suicide in the year 1915.</p>

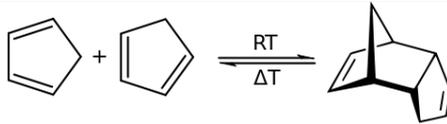
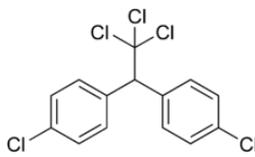
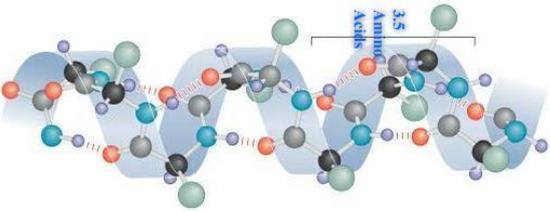
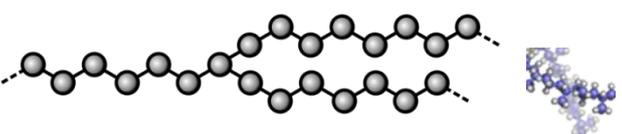
Epoch	1850 → Chemistry of the Modern Age		
AM  1915	<i>Theory of the noble gas configuration and octet rule</i>		
Cl ₂ 1915		Gas attack of the Germans with chlorine gas at the beginning of the second Flemish Battle in World War I	
1916	Wilhelm Lommel Wilhelm Steinkopf	Proposal on the use of sulfur mustard as a weapon war <chem>Cl-CH2-CH2-S-CH2-CH2-Cl</chem> (LOST)	
AM  1916	Arnold Sommerfeld	<i>Bohr-Sommerfeld's Atomic Model</i>	
1918 AN	Arthur Jeffrey Dempster	Design of the first modern mass spectrometer	
1919 CAS	Founding of the International Union of Pure and Applied Chemistry (IUPAC)		
1920 AN	Fritz Feigl	 PhD Thesis "On the Use of Spotting Reactions in Quantitative Analysis" Pioneer of Chromatography	
1921 NO	Nernst	1921 Nobel Prize awarded in chemistry for the work on thermochemistry	
1921 BASF	Explosion at BASF's Oppau Plant, killing 500 people		
1921 BAY	Bayer announces a patent on which today's process for the production of <i>Aspirin</i> is based.	<chem>CC(=O)Oc1ccccc1C(=O)O</chem>	
1922 NO	Albert Einstein	Nobel Prize awarded in physics for the discovery of the law of the <i>Photoelectric Effect</i> for the year 1921	
1923 AN NO	Fritz Pregl	Nobel Prize awarded in chemistry, for the development of microanalysis of organic substances	 
1923 PC	<p>Peter Debye 1884-1966 1936 Nobel Prize Awarded in Chemistry</p> 	<p>Erich Hückel 1896-1980 Chemist/Physicist</p> 	<p>Lars Onsager 1903-1976 Physical Chemist 1968 Nobel Prize Awarded in Chemistry</p>  <p><i>Debye-Hückel-Onsager Theory</i> on the properties of dilute electrolyte solutions</p> 
AM  1924 NO	Louis de Broglie Physicist	Postulation of matter waves, wave / particle duality In 1929 Nobel Prize awarded in physics <i>de Broglie Wavelength</i>	 

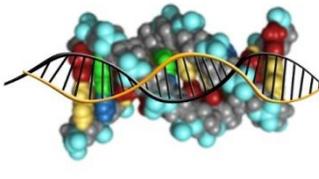
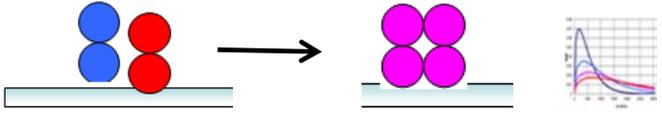
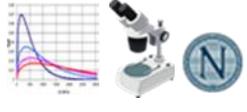
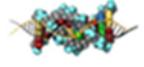
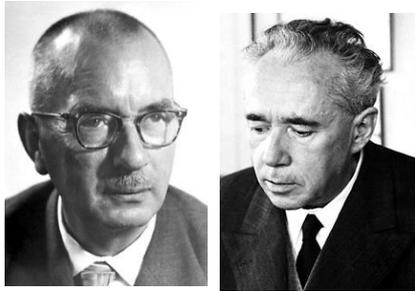
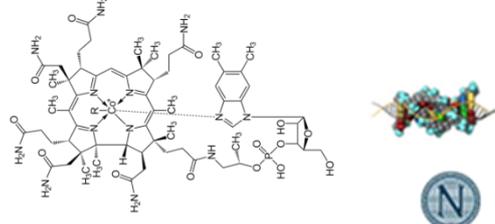
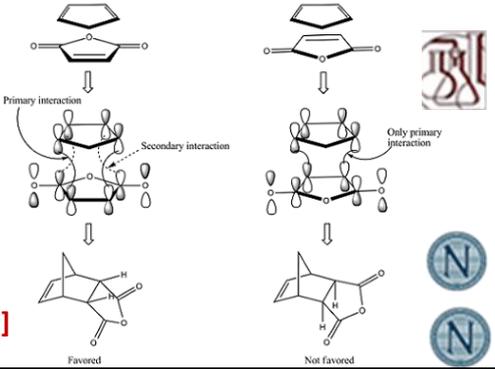
Epoch	1850 → Chemistry of the Modern Age			
<p>AM</p> 	<p>Erwin Schrödinger 1887-1961 Physicist</p> 	<p>Max Born 1882-1970 Physicist</p> 	<p>Wolfgang Ernst Pauli 1900-1958 Physicist</p> 	<p>Werner Karl Heisenberg 1901-1976 Physicist</p> 
Development of quantum mechanics and wave mechanics				
<p>AM</p> 	<p>Pauli</p>	<p>Statement of the Pauli Exclusion Principle. Electrons of an atom differ from each other, none resembles another (1945 Nobel Prize awarded in physics)</p> 		
<p>1925 NO</p>	<p>Friedrich Hund</p>	<p>Development of Hund's Rules</p>		
<p>1925 BASF BAY</p>		<p>Founding of the I.G. Farben from a numerous chemical companies</p>  		
<p>AM</p> 	<p>Werner Karl Heisenberg</p>	<p>Heisenberg's Uncertainty Principle:</p> $\Delta x \cdot \Delta p \geq \frac{h}{4 \cdot \pi}$ <p>Two complementary properties of a particle can be determined with any precisely at the same time (1932 Nobel Prize awarded in physics)</p> 		
<p>AM</p> 	<p>Erwin Schrödinger</p>	<p>Development of wave mechanics - Schrödinger Equation (1933 Nobel Prize awarded in physics, along with Paul Dirac)</p> $H \cdot \Psi = E \cdot \Psi$ 		
<p>AM</p> 	<p>Max Born</p>	<p>Statistical interpretation of quantum mechanics - > theory of chemical bond 1954 Nobel Prize in Physics</p>  		
<p>1926</p>	<p>Albert Einstein 1879-1955 Physiker</p> 	<p>Letter from Albert Einstein to Max Born: "Quantum mechanics is very impressive. However an inner voice tells me that this is not the whole truth. The theory provides much, but it hardly brings us closer to the mystery of the old. Anyway, I'm sure "God does not play dice with the universe"</p>  		

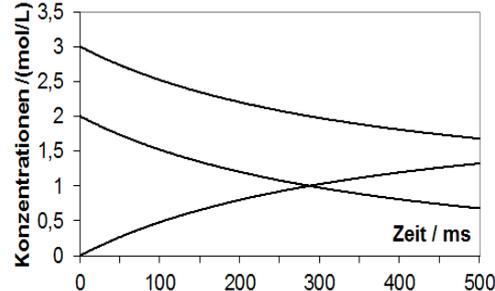
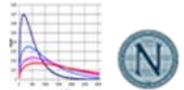
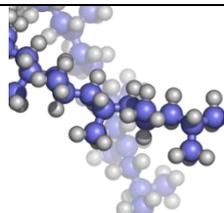
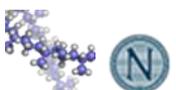
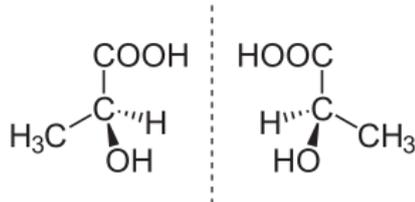
Epoch	1850 → Chemistry of the Modern Age	
1926 PC BC NO	The Svedberg Chemist	Nobel Prize awarded in chemistry for the scientific work on disperse systems   
H₂SO₄	Production of sulfur trioxide according to the contact process with vanadium pentoxide as catalyst (Chemico) 	
1927		
AM  1927	Bohr Heisenberg Born	Statement of the <i>Copenhagen Interpretation</i> 
1928 OC NO	Albert von Szent-Györgyi Nagyrápolt	 Isolation of vitamin C [2] (1937 Nobelprize awarded in physiology or medicine)  
ZU  1928 BC NO	Alexander Fleming 1881-1955 Bacteriologist	 Discovery of penicillin [2] 1945 Nobel Prize awarded in physiology or medicine along with Howard Walter and Ernst Boris Chain  
1931 BAY	Bayer removes heroin from the product range 	
1932 PC NO	Irving Langmuir 1881-1957 Chemist Physicist [3]	  Nobel Prize awarded in chemistry for the discoveries and work on surface  
E E 1933 NO	Irene Joliot Curie 1897-1956 Physicist	N Presentation of a new radioactive element, an isotope of nitrogen   1934 Nobel Prize awarded in chemistry, along with her husband Frederic Joliot 
E E 1934 NO	Harold Clayton Urey	H Nobel Prize awarded in Chemistry for the discovery of heavy Hydrogen (1931) 
1935 PO	Wallace Hume Carothers	 The pioneer in the field of polycondensation reactions develops Nylon [3] 

Epoch	1850 → Chemistry of the Modern Age	
1935	Erwin Schrödinger	Thought experiment "Schrödinger's cat"
1935 PC	Henry Eyring 1901-1981	Eyring Theory [3] : Publication of the theory concerning the activated complex in chemical reactions
1936 PC NO	Peter Debye	Nobel Prize awarded in chemistry for the research on dipole moments
1937 BC NO	Sir Hans Adolf Krebs 1900-1981 Physician Biochemist	Discovery of the citrate cycle (1953 Nobel Prize awarded in physiology or medicine)
1938	Konrad Zuse 1910-1995 Civil engineer Inventor Entrepreneur	Zuse completes the Z1, the first binary calculating machine.
1940 PO	Dupont sells the first five million pairs of nylon stockings ("N-Day") in selected stores in US metropolises.	
1940 NO	George Hevesy	Dissolving physics Nobel medals in aqua regia [3]
1941	Konrad Zuse	Zuse manufactures the Z3, the first electromechanical, freely programmable calculating machine. Zuses offer to the army to build an electronic calculator was rejected.
1943 NO	George Hevesy	Nobel Prize awarded in Chemistry for the method of isotope labeling
ZU 1943 OC	Albert Hofmann 1906-2008 Chemist	Discovery of LSD [3] (April 19, 1943 Bicycle Day)
1945 NO	Wolfgang Pauli	Nobel Prize awarded in physics for the formulation of the Pauli Exclusion Principle
1945 NO	Otto Hahn 1879-1968 Chemist	Nobel Prize awarded in chemistry for the discovery of nuclear fission (radiochemical analysis 1944)
	Alexander Flemming	Nobel Prize awarded in physiology or medicine for the discovery of penicilline
1946 BC NO	Ulf Svante von Euler-Chelpin	Discovery of norepinephrine as chemical information transmitter in nerve fibers (1970 Nobel Prize awarded in physiology or Medicine)

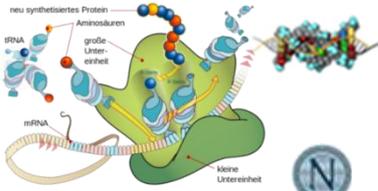


Epoch	1850 → Chemistry of the Modern Age	
1947 BASF BAY		<p>IG Farben court hearing from a US military court</p> <p>Charges: war crimes, crimes against peace, initiation and conduct of aggressive wars, crimes against humanity in the Third Reich. The IG Farben used concentration camp prisoners from Auschwitz for forced labor during the war.</p>
1949 CAS	<p>Founding of the Gesellschaft Deutscher Chemiker (GDCh)</p>	
1950 OC NO	<p>Otto Diels 1876-1954 Chemist</p> <p>Kurt Alder 1902-1958 Chemist</p>	 <p>Nobel Prize awarded in Chemistry, for the [4+2]-cycloaddition (Diels-Alder-Reaction)</p>
1950-1960 OC		<p>Production of many poorly degradable chlorine compounds</p> <p>DDT (insecticide) PCB (belongs to the "dirty dozen")</p>
1950 BAY	<p>Reconstruction of Bayer</p>	
E 1950	Nb	<p>IUPAC defines the name niobium for the element Columbium</p> 
1950 BC NO	<p>Linus Carl Pauling 1901-1994 Chemist</p>	 <p>Discovery of α-helix in proteins by X-ray diffraction (1954 Nobel Prize awarded in chemistry)</p>
E 1952	Es	<p>Discovery of the artificial element Einsteinium after the test of the first American hydrogen bomb</p> 
1952 OC	<p>Stanley Miller H.C. Urey</p>	<p>Miller Urey-Experiment, Creation of artificial urine atmosphere for the synthesis of organic molecules [3]</p>
1953 PO NO	<p>Hermann Staudinger 1881-1965 Chemist</p>	<p>Nobel Prize awarded in chemistry for discoveries in the field of macromolecular chemistry</p> 

Epoch	1850 → Chemistry of the Modern Age	
1953 BC NO	Francis Crick James Watson Maurice Hugh Frederick Wilkins [3]	 <p>Publication of the molecular structure of deoxyribonucleic acid (1962 Nobel Prize awarded in physiology or medicine)</p> 
1956 PC	Cyril Norman Hinshelwood 1897-1967 Chemist	 <p>Nobel Prize awarded in chemistry along with Semenov, for the research on the mechanisms of chemical reactions</p> 
1959 PC AN NO	Jaroslav Heyrovský 1890-1967	<p>Nobel Prize awarded in chemistry for the development of polarography</p>  
Cl ₂ 1960 BAY	Bayer Material Science becomes one of the world's largest chlorine producers	
1961 BC	Marshall Warren Nirenberg Har Gobind Khorana	<p>Poly-U experiment (first identification of a genetic code) (1962 Nobel Prize awarded in physiology or medicine)</p> 
1963 PO NO	Karl Ziegler 1898-1973 Chemist Giulio Natta 1903-1979 Chemist	 $\text{Cl}_2\text{Ti}(\text{CH}_3)_2 \longrightarrow \text{Cl}_2\text{Ti}(\text{H})\text{CH}_3 + \text{H}_3\text{C}-\text{C}(\text{H})=\text{CH}_2$ <p>Nobel Prize awarded in Chemistry for the reactions to the chemistry of High-Polymers (Ziegler-Natta Process)</p> 
1964 BC NO	Dorothy Crowfoot Hodgkin [2] 1910-1994 Chemist	<p>Nobel Prize awarded in chemistry for X-ray analysis and structure determination of vitamin B12</p>  
1965 OC NO	Robert Burns Woodward [2] 1917-1979 Chemist Roald Hoffmann 1937 Chemist	<p>1965 Nobel Prize awarded in chemistry (Woodward) [2]</p> <p>1981 Nobel Prize awarded in Chemistry (Hoffmann along with Fukui Ken'ichi)</p> <p>Woodward-Hoffmann- Rules [2]</p>    

Epoch	1850 → Chemistry of the Modern Age	
1967 PC NO	<p>Manfred Eigen</p> <p>R. George Wreyford Norrish</p> <p>G. Porter</p>	 <p>Nobel Prize awarded in Chemistry for the studies on fast chemical reactions</p> 
1967		<p>In 1967 the first electronic calculator was developed by Texas Instruments.</p>
1967 AN	Csaba Horvath	<p>Construction of the first modern HPLC apparatus [3]</p> 
1968 PC	<p>Presentation of the <i>Belousov-Zhabotinsky Reaction</i> at a conference [3]</p> 	
1968 PC NO	Lars Onsager	<p>Nobel Prize awarded in Chemistry for the <i>Onsager reciprocal relations</i></p> 
1970	<p>First computer chemistry software <i>Gaussian 70</i></p>	
1970		<p>Introduction of the <i>SI Unit Watt</i> in Germany for power, named after <i>James Watt</i> (1736-1819), the Scottish inventor, who achieved a considerable improvement in the efficiency of steam engines.</p>
1970	John. E. Franz	<p>Discovery of glyphosphate as a herbicide [3]</p>
1971	<p>John Wesley Hyatt 1837-1920</p>	<p>Admission to the Hall of Fame of the Billiards Congress of America for the development of celluloid billiard balls</p> 
1971	<p>Defining the mole as the last SI base unit</p>	
1974 PO NO	<p>Paul Flory 1910-1985</p>	<p>Nobel Prize awarded in chemistry for the basic achievements in physical chemistry of macromolecules, both theoretical and experimental.</p>  
1974		<p>Above all other manufacturers Hewlett Packard and Texas Instruments developed starting from 1974 programmable calculators</p>
1975 OC NO	<p>Vladimir Prelog 1906-1998 Chemist</p>	 <p>Nobel Prize awarded in chemistry for research in the Stereochemistry of organic molecules and reactions</p> 

Epoch	1850 → Chemistry of the Modern Age	
1977 PC NO	Ilya Prigogine 1917-2003 Chemist	Nobel Prize awarded in Chemistry for the contribution to irreversible thermodynamics, in particular to the theory of "dissipative structures"
1977	Aspirin is added to the WHO essential medicine list	
1984 OC NO	Robert Bruce Merrifield Chemist	Nobel Prize awarded in chemistry for the simple and ingenious method applied to the preparation of peptides and proteins (Merrifield synthesis)
1990 BC		Start of the human genome project
1990 OC NO	Elias James Corey Chemist	Nobel Prize awarded in chemistry for the Development of theory and methodology of synthesis of organic compounds (Retrosynthesis)
1990 CAS	CAS (Chemical Abstracts Service) 10 million registered chemical compounds	
1991 AN NO	Richard Robert Ernst 1933 Chemist	Nobel Prize awarded in chemistry for contributions to the development of high-resolution nuclear magnetic resonance spectroscopy, a method for the analysis of molecular structures
E 1997	Mt	Designation of the chemical element with the atomic number 109 as Meitnerium , according to Lise Meitner
Na₂CO₃ 1997	The global soda production is 39 million t / a. Soda is an important raw material for the modern world. It is used for glassmaking, for the production of bleaching agents, detergents and in papermaking.	
2000 CAS	CAS (Chemical Abstracts Service) 22 million registered chemical compounds	
2003 BC		Complete decryption of the human genome
Cl₂ 2006 PO	Worldwide chlorine production amounts to 58.9 million t/a. Chlorine is used to make many other starting materials, especially for Vinyl chloride to obtain the polymer PVC (polyvinyl chloride).	

Epoch	1850 → Chemistry of the Modern Age		
2005 OC NO	Yves Chauvin Howard Grubbs Royce Schock	Nobel Prize awarded in chemistry for Alkenmethasynthesis	 
NH ₃ 2007 PC NO	Gerhard Ertl Physicist Chemist	Nobel Prize awarded in chemistry for the development of surface chemistry including the elucidation of the mechanism for ammonia synthesis	 
2008 CAS	The <i>Landolt-Börnstein</i> comprises 350 volumes		 
2008 CAS		SciFinder a database developed by CAS is present on the web.	
H ₂ SO ₄ 2009	Sulfuric acid production amounts to more than 200 million tons per year worldwide. Sulfuric acid is the most widely produced chemical in the world. Sulfuric acid is called " <i>the blood of chemistry</i> ", and finds applications in many areas of life, for example in car batteries as an electrolyte.		
2009 BC NO	Ada Yonath Structural Biologist	Nobel Prize awarded in Chemistry along with Venkatraman Ramakrishnan and Thomas A. Steitz for the study on the structure and function of the ribosome.	 
2011 CAS	CAS (Chemical Abstracts Service) 60 million registered chemical compounds		
NH ₃ 2013	The global ammonia production is 140 million t / a. Ammonia synthesis has changed the world. It consumes 1.4% of the world's energy consumption, provides food for half of mankind and enables the production of huge quantities of explosives.		
2013 AN	Felix R. Fischer Michael Crommie	First pictures of molecular alteration during a chemical reaction with atomic force microscopy	
2014 AN NO	Stefan Hell Eric Betzig William E. Moerner	Nobel Prize awarded in chemistry for the development of super-resolution fluorescence microscopy	 
2015 CAS	CAS / SciFinder 101 million registered chemical compounds, 66 million nucleotide sequences, 62 million reactions, 5.8 billion registered substances records		
2016 OC NO	Jean- Pierre Sauvage Fraser Stoddart Ben Feringa	Nobel Prize in chemistry for the design and the synthesis of molecular machines	 
2017 CAS	CAS / SciFinder: every day 15,000 new substances are registered		
2018 BC NO	Francis Hamilton Arnold	Nobel Prize awarded in chemistry for the directed evolution of enzymes	 

History of Chemistry TIMELINES Overview 2 The path to chemistry of modern



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[1]

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[2]

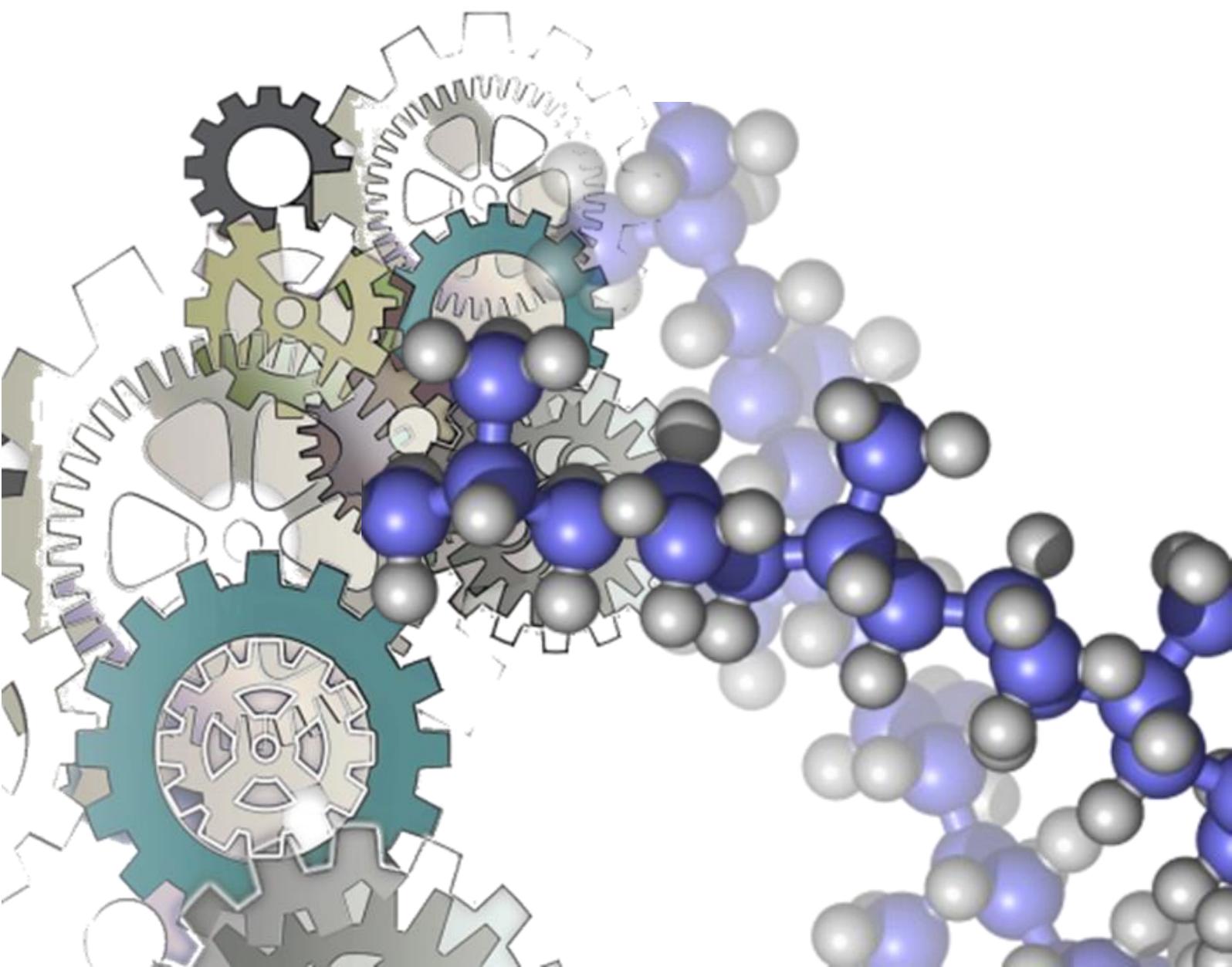
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[3]

Derek B. Lowe, The Chemistry Book: From Gunpowder to Graphene, Sterling Publishing Co Inc, New York, 2016, ISBN10: 1454911808

[4]

M.E. Chevreul, A Chemical Study of Oils and Fats of Animal Origin, Translated and annotated by Albert J. Dijkstra, edited by Gary R. List and Jaime Wisniak, 2009, ISBN 978-2-9533244-0-2



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Prof. Dr. rer. nat. Peter Swidersky
Physical Chemistry
Chemical Reaction Engineering



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Peter Swidersky 14.11.2022

