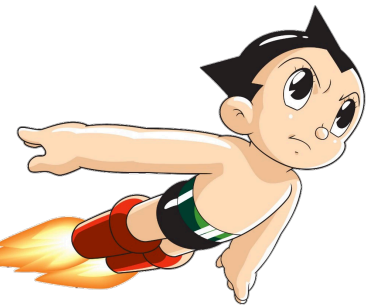
Atomic Physics

Introduction



2018年原子物理课程

该二维码7天内(9月24日前)有效，重新进入将更新

How to be a good teacher

南開大學

这是当老师前，我眼中的学生

这是当老师后，我眼中的学生

当老师之前，满怀理想的我

当老师之后，面对现实的我

How to be a good teacher

这是上课之前，我跟学生的关系

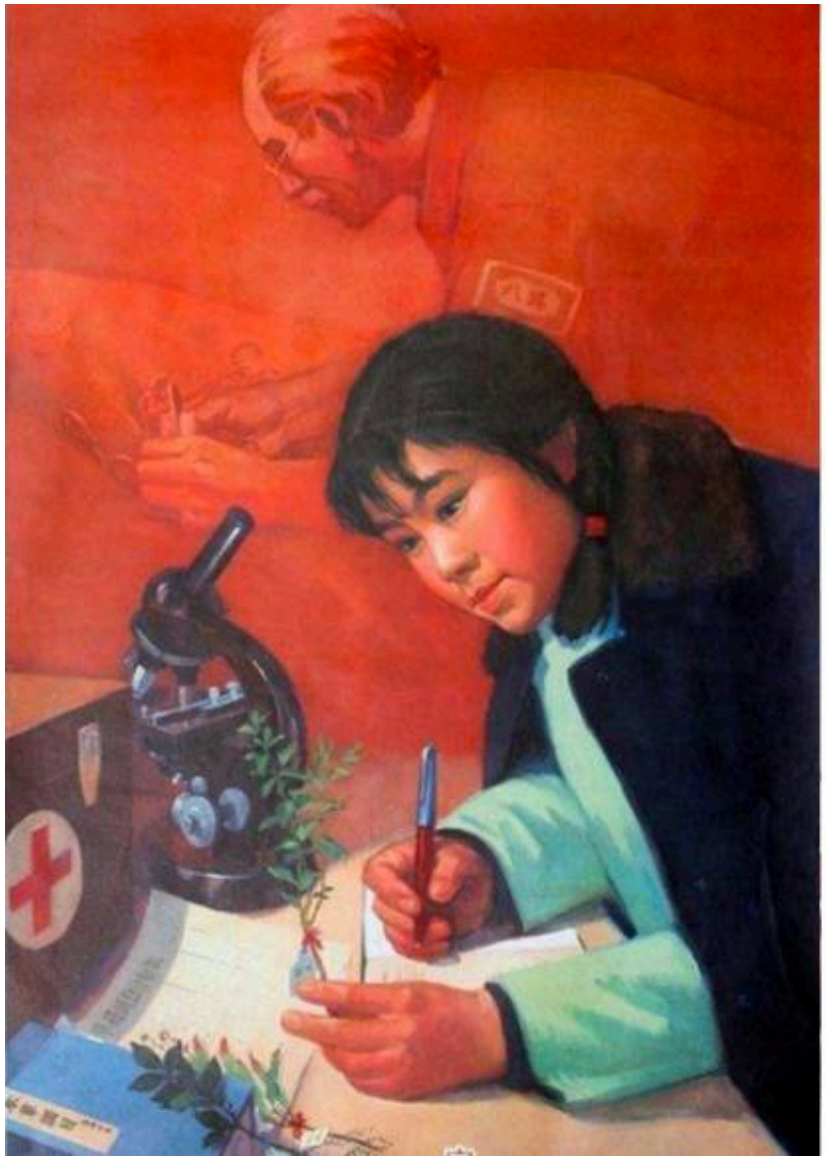
这是上课之时，我跟学生的关系

这是下课之后，我跟学生的关系

How to be a good teacher

为了阻止学生考试作弊，我的视觉，嗅觉都进化了。

How to be a good teacher



因为经常熬夜加班备课，我的抵抗力变强了

以前我很羡慕那些将事业跟生活分开的老师，不仅事业成功，生活也过的有滋有味。觉得他们才是生活的赢家。

后来我发现，一名老师，如果能培养出考试不作弊，课上不淘气，上课很积极，不点名，不迟到，看见老师能问好，知道写论文的时候自己查资料的学生，才是真正的生活的赢家！

Class requirements

南開大學

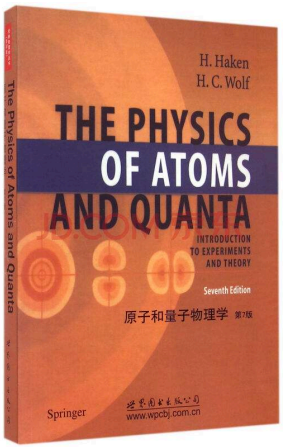
- ✓ Quiz+Homework (30%)
- ✓ Final examination (70%)
- ✓ References

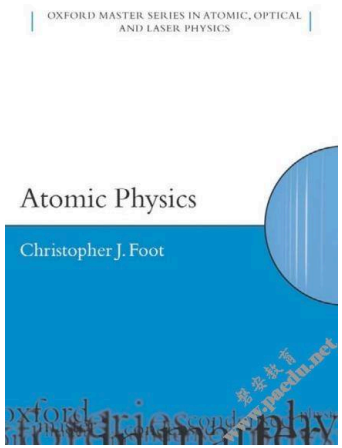
H. Haken and H. C. Wolf, The physics of Atom and Quanta

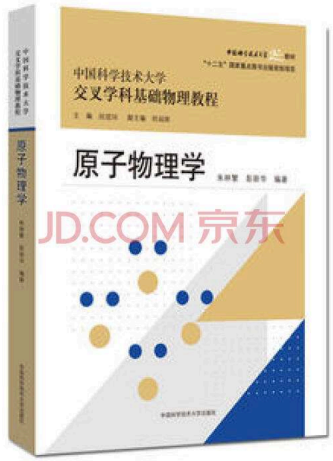
C. J. Foot, Atomic Physics

杨福家，原子物理学 第四版

褚圣麟，原子物理学







2018年原子物理课程

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Cosmic Uroboros

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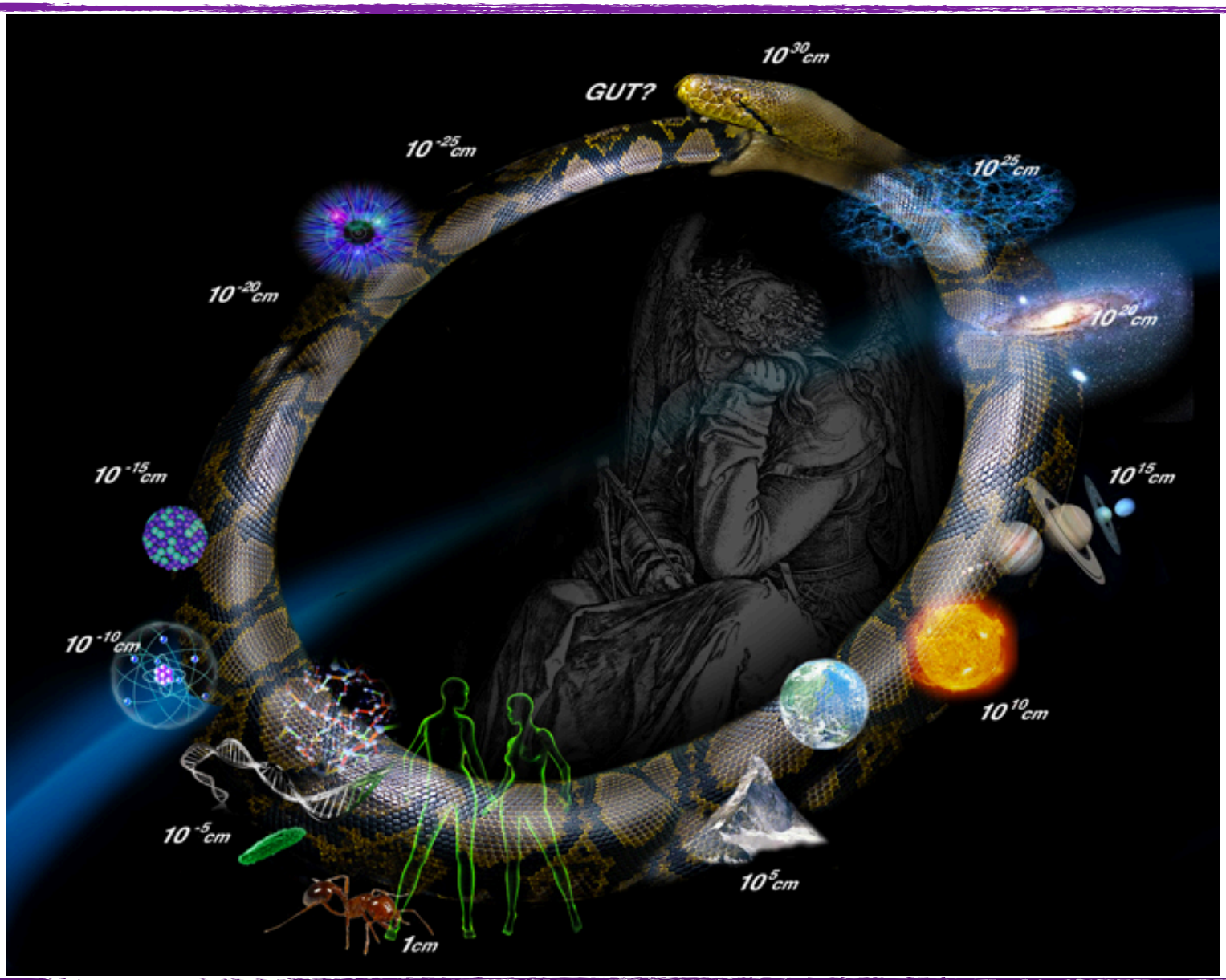
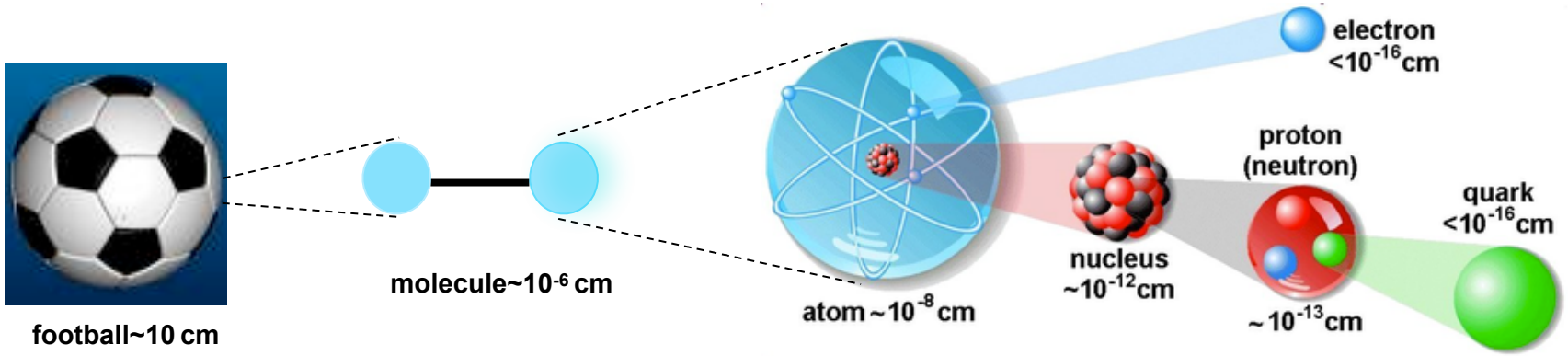
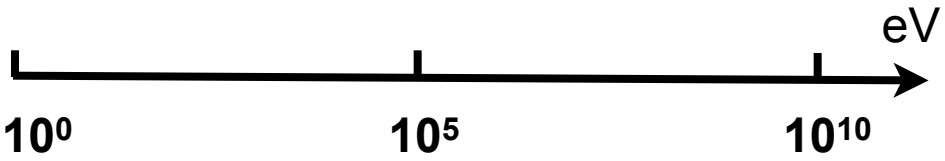


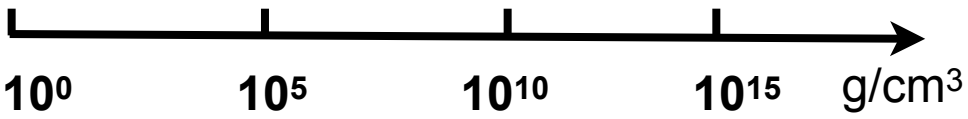
Atom size



Range of excitation energies



Range of densities

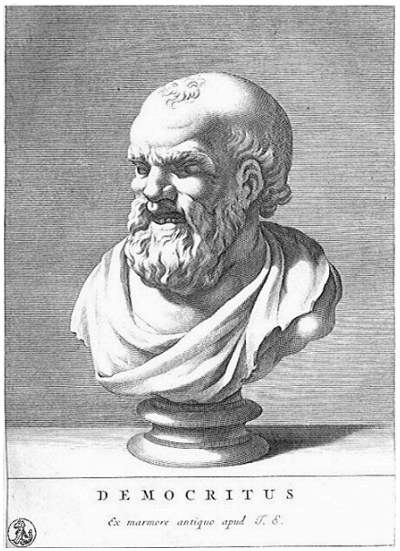


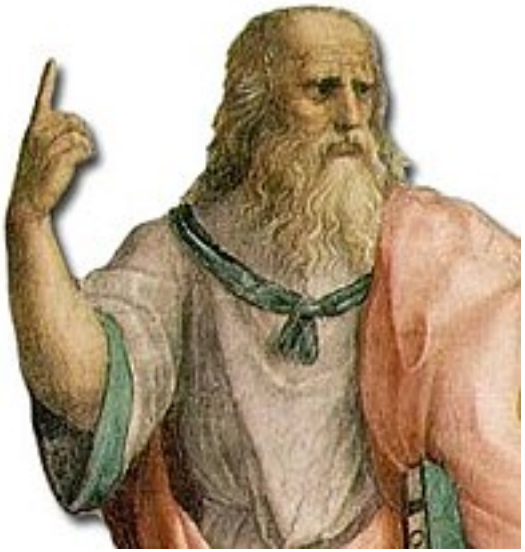
Short Historical Review

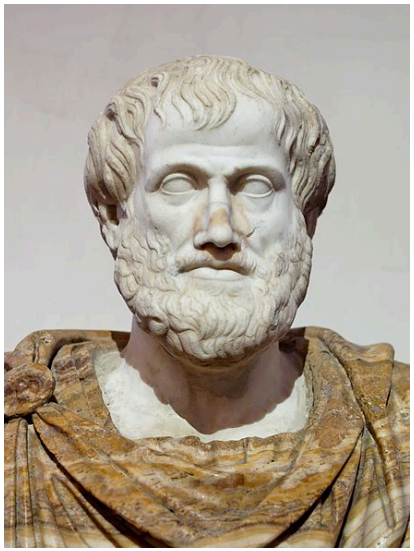
✓ Atom comes from the Greek and means "the indivisible", the smallest component of matter, which cannot be further divided.

✓The first atomic theories of the structure of matter were those of Democrites (460 - 370 B.C.), Plato (429 - 348), and Aristotle (384- 322).

Democracy

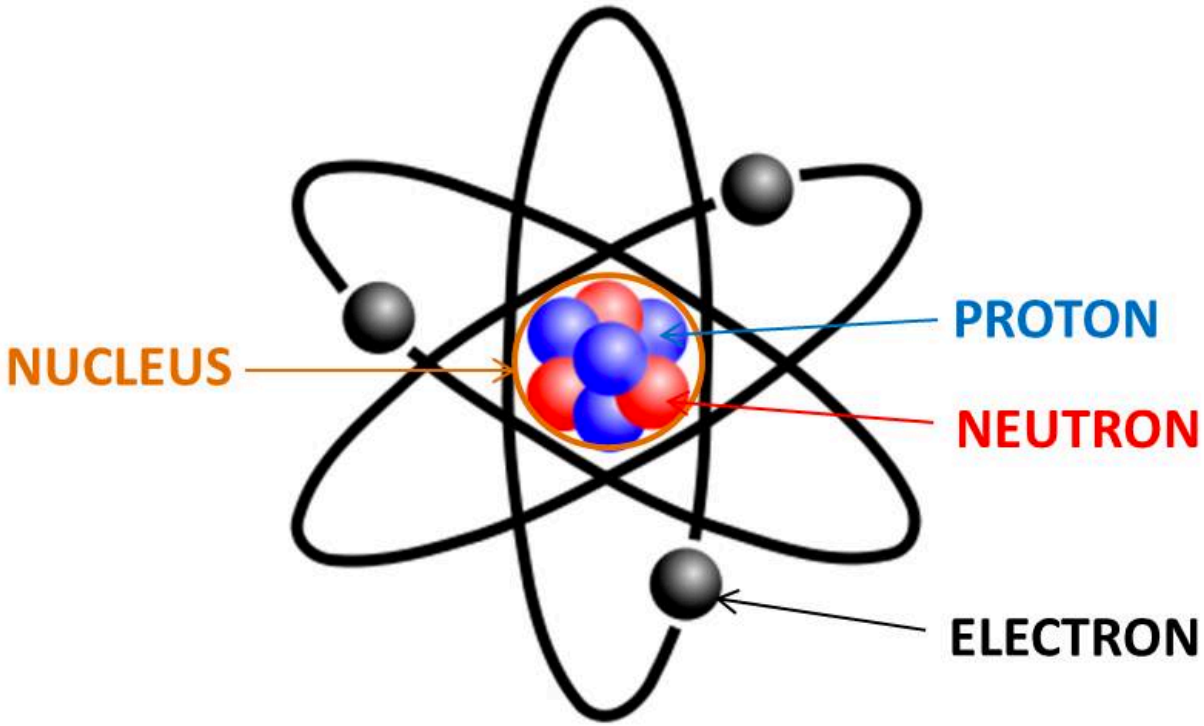






Short Historical Review

✓ The meaning of the word "atom" becomes less subject to misinterpretation if it is translated into Latin: an individuum （不可分） is the smallest unit of a large set which possesses all the essential characteristics of the set.



Short Historical Review

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✓ All the chemical elements are composed of atoms were recognized from **chemical investigations**.

✓ The laws of constant and multiple proportions:
(J. L. Proust and Dalton)

In a mixture of non-reacting gases, the total pressure exerted is equal to the sum of the partial pressures of the individual gases. （在组分之间不发生化学反应的前提下，理想气体混合物的压强等于各组分的分压之总和）

✓1815 The first atomic model (W. Prout):

The atoms of all elements are put together out of hydrogen atoms.

Short Historical Review

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✓1808 The volume of gaseous reactants occur as ratios of small integers (Gay-Lussac)

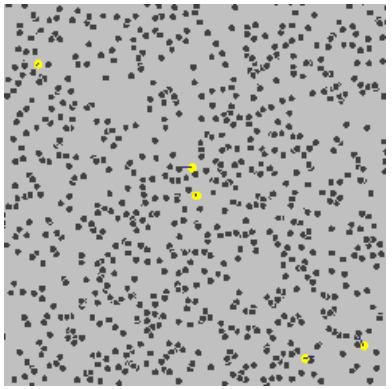
（在同温同压下，气体相互之间按照简单体积比例进行反应，并且生成的任一气体产物也与反应气体的体积成简单整数比）

✓1811 Hypothesis of Avogadro:

Equal volumes of gases under similar conditions contain equal numbers of molecules.

✓1826 Brown motion:

The random motion of particlessuspended in a fluid(a liquid or a gas) resulting from their collision with the fast-moving atoms or molecules in the gas or liquid.



Short Historical Review

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✓ 1833, Faraday laws:

1. The quantity of an element which is separated is proportional to the quantity of charge transported in the process.
2. Various elements are separated into equivalent weights by the same quantity of charge.

1. 物质在电解过程中，参与电极反应的质量与通过电极的电量成正比。
2. 不同物质电解的质量则正比于该物质的化学当量。

Short Historical Review

✓ 1869, Periodic table (L. Meyer and D. I. Mendeleev)

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ,

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,1.
			Fe=56	Ru=104,4	Ir=198.
			Ni=Co=59	Pd=106,6	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be= 9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,3	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Д. Менделѣевъ

Short Historical Review

南開大學

✓ 1869, Periodic table (L. Meyer and D. I. Mendeleev)

Д. Менделѣевъ

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ,

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

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			Fe=56	Ru=104,4	Ir=198.	
		Ni=Co=59		Pd=106,6	Os=199.	
H=1			Cu=63,4	Ag=108	Hg=200.	
	Be= 9,4	Mg=24	Zn=65,2	Cd=112		
	B=11	Al=27,3	?=68	Ur=116	Au=197?	
	C=12	Si=28	?=70	Sn=118		
	N=14	P=31	As=75	Sb=122	Bi=210?	
	O=16	S=32	Se=79,4	Te=128?		
	F=19	Cl=35,5	Br=80	I=127		
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.	
		Ca=40	Sr=87,6	Ba=137	Pb=207.	
		?=45	Ce=92			
		?Er=56	La=94			
		?Yt=60	Di=95			
		?In=75,6	Th=118?			

PRODUCED BY THE FOUNDATION FOR EDUCATION, SCIENCE AND TECHNOLOGY FOR NATIONAL SET WEEK 2003

PERIODIC TABLE of the ELEMENTS

DEPARTMENT OF SCIENCE AND TECHNOLOGY

Proudly sponsored by the SHUTTLEWORTH FOUNDATION supporting social innovation

ALKALI METALS
ALKALI EARTH METALS
TRANSITION METALS
OTHER METALS
OTHER NONMETALS
HALOGENS
NOBLE GASSES
RARE EARTH METALS

At room temperature the element is:
Gas
Liquid
Natural solid
Man-made solid [synthetic]

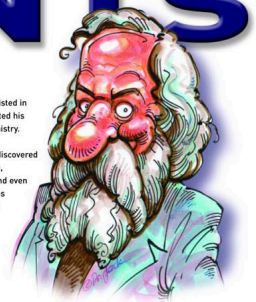
Hydrogen 1 1.01 (Symbol, Element name, Atomic number, Atomic mass)

DMITRI MENDELEYEV (1834 – 1907)

The Russian chemist, Dmitri Mendeleyev, was the first to observe that if elements were listed in order of atomic mass, they showed regular (periodicall repeating properties. He formulated his discovery in a periodic table of elements, now regarded as the backbone of modern chemistry.

The crowning achievement of Mendeleyev's periodic table lay in his prophecy of then, undiscovered elements. In 1869, the year he published his periodic classification, the elements gallium, germanium and scandium were unknown. Mendeleyev left spaces for them in his table and even predicted their atomic masses and other chemical properties. Six years later, gallium was discovered and his predictions were found to be accurate. Other discoveries followed and their chemical behaviour matched that predicted by Mendeleyev.

This remarkable man, the youngest in a family of 17 children, has left the scientific community with a classification system so powerful that it became the cornerstone in chemistry teaching and the prediction of new elements ever since. In 1955, element 101 was named after him: Md, Mendelevium.



IA 1	IIA 2	III B 3	IV B 4	V B 5	VI B 6	VII B 7	VIII 8	VIII 9	VIII 10	I B 11	II B 12	III A 13	IV A 14	V A 15	VI A 16	VII A 17	VIII A 18
1 H Hydrogen 1 1.01																	2 He Helium 2 4.00
2 lithium 3 6.94 Li	4 Be Beryllium 4 9.01											5 B Boron 5 10.81	6 C Carbon 6 12.01	7 N Nitrogen 7 14.01	8 O Oxygen 8 16.00	9 F Fluorine 9 19.00	10 Ne Neon 10 20.18
3 Na Sodium 11 22.99	12 Mg Magnesium 12 24.31											13 Al Aluminium 13 26.98	14 Si Silicon 14 28.09	15 P Phosphorus 15 30.97	16 S Sulphur 16 32.06	17 Cl Chlorine 17 35.45	18 Ar Argon 18 39.95
4 K Potassium 19 39.10	20 Ca Calcium 20 40.08	21 Sc Scandium 21 44.96	22 Ti Titanium 22 47.88	23 V Vanadium 23 50.94	24 Cr Chromium 24 52.00	25 Mn Manganese 25 54.94	26 Fe Iron 26 55.85	27 Co Cobalt 27 58.93	28 Ni Nickel 28 58.69	29 Cu Copper 29 63.55	30 Zn Zinc 30 65.39	31 Ga Gallium 31 69.72	32 Ge Germanium 32 72.61	33 As Arsenic 33 74.92	34 Se Selenium 34 78.96	35 Br Bromine 35 79.90	36 Kr Krypton 36 83.80
5 Rb Rubidium 37 85.47	38 Sr Strontium 38 87.62	39 Y Yttrium 39 88.91	40 Zr Zirconium 40 91.22	41 Nb Niobium 41 92.91	42 Mo Molybdenum 42 95.94	43 Tc Technetium 43 (98)	44 Ru Ruthenium 44 101.07	45 Rh Rhodium 45 102.91	46 Pd Palladium 46 106.42	47 Ag Silver 47 107.87	48 Cd Cadmium 48 112.41	49 In Indium 49 114.82	50 Sn Tin 50 118.71	51 Sb Antimony 51 121.76	52 Te Tellurium 52 127.60	53 I Iodine 53 126.90	54 Xe Xenon 54 131.29
6 Cs Caesium 55 132.91	56 Ba Barium 56 137.33	Lanthanide Series	72 Hf Hafnium 72 178.49	73 Ta Tantalum 73 180.95	74 W Tungsten 74 183.85	75 Re Rhenium 75 186.21	76 Os Osmium 76 190.23	77 Ir Iridium 77 192.22	78 Pt Platinum 78 195.08	79 Au Gold 79 196.97	80 Hg Mercury 80 200.59	81 Tl Thallium 81 204.38	82 Pb Lead 82 207.20	83 Bi Bismuth 83 208.98	84 Po Polonium 84 (209)	85 At Astatine 85 (210)	86 Rn Radon 86 (222)
7 Fr Francium 87 (223)	88 Ra Radium 88 (226)	Actinide Series	104 Rf Rutherfordium 104 (261)	105 Db Dubnium 105 (262)	106 Sg Seaborgium 106 (263)	107 Bh Bohrium 107 (262)	108 Hs Hassium 108 (265)	109 Mt Meitnerium 109 (266)									

57 La Lanthanum 57 138.91	58 Ce Cerium 58 140.12	59 Pr Praseodymium 59 140.90	60 Nd Neodymium 60 144.24	61 Pm Promethium 61 (145)	62 Sm Samarium 62 150.36	63 Eu Europium 63 151.96	64 Gd Gadolinium 64 157.25	65 Tb Terbium 65 158.92	66 Dy Dysprosium 66 162.50	67 Ho Holmium 67 164.93	68 Er Erbium 68 167.26	69 Tm Thulium 69 168.93	70 Yb Ytterbium 70 173.04	71 Lu Lutetium 71 174.96
89 Ac Actinium 89 227.02	90 Th Thorium 90 232.03	91 Pa Protactinium 91 231.03	92 U Uranium 92 238.02	93 Np Neptunium 93 (237)	94 Pu Plutonium 94 (244)	95 Am Americium 95 (243)	96 Cm Curium 96 (247)	97 Bk Berkelium 97 (247)	98 Cf Californium 98 (251)	99 Es Einsteinium 99 (254)	100 Fm Fermium 100 (257)	101 Md Mendelevium 101 (258)	102 No Nobelium 102 (259)	103 Lr Lawrencium 103 (260)

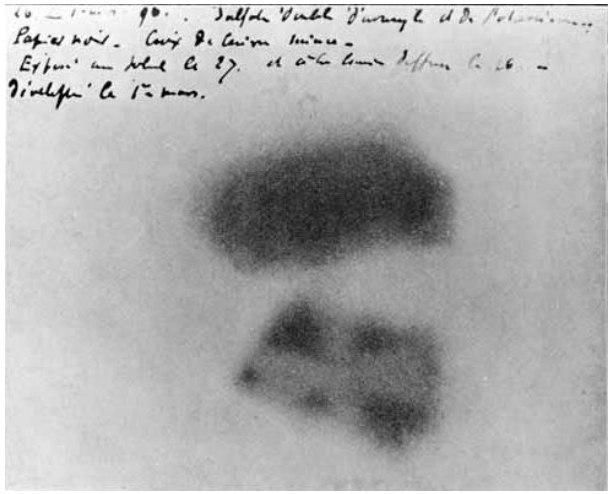
Design and production: Loretta Steyn Graphic Design Studio - Pretoria **Illustrations:** Dr. Jack **Technical advisors:** Carl Ahlers - Esperisa

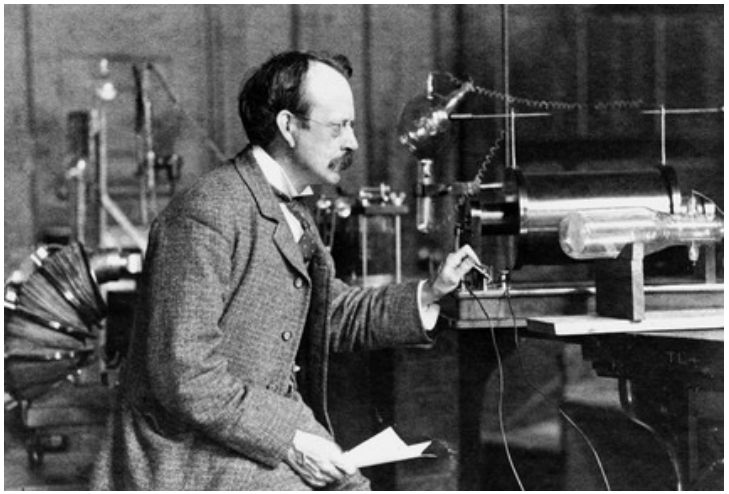
Public Understanding of Science, Engineering and Technology

FEST Foundation for Education, Science & Technology

Short Historical Review

- ✓ 1885, Ordering principle in atomic spectra (J. Balmer)
- ✓ 1895, X ray (W. Roentgen)
- ✓ 1896, Radiation (A. H. Becquerel)
- ✓ 1897, The discovery of electron (J. J. Thomson)





Short Historical Review

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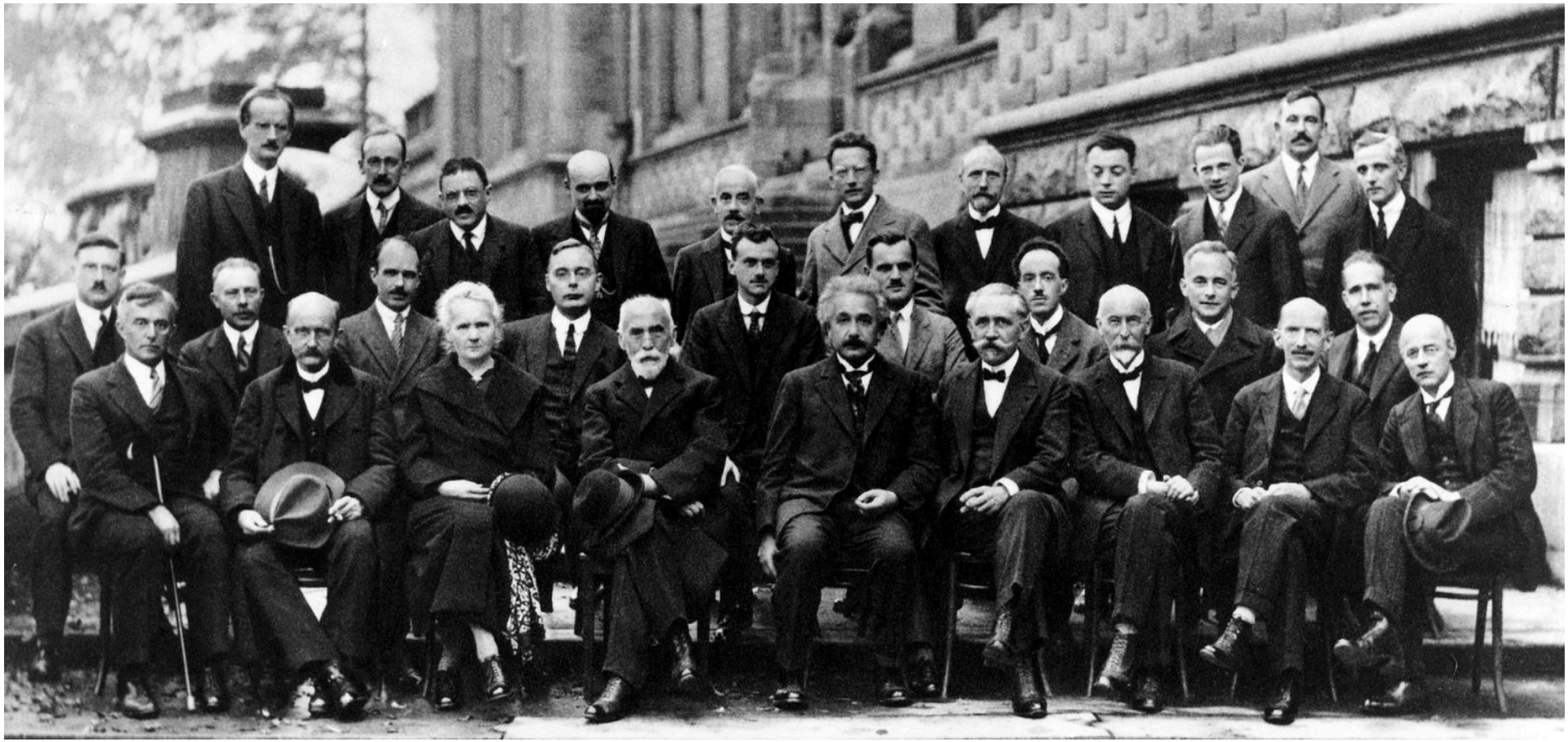
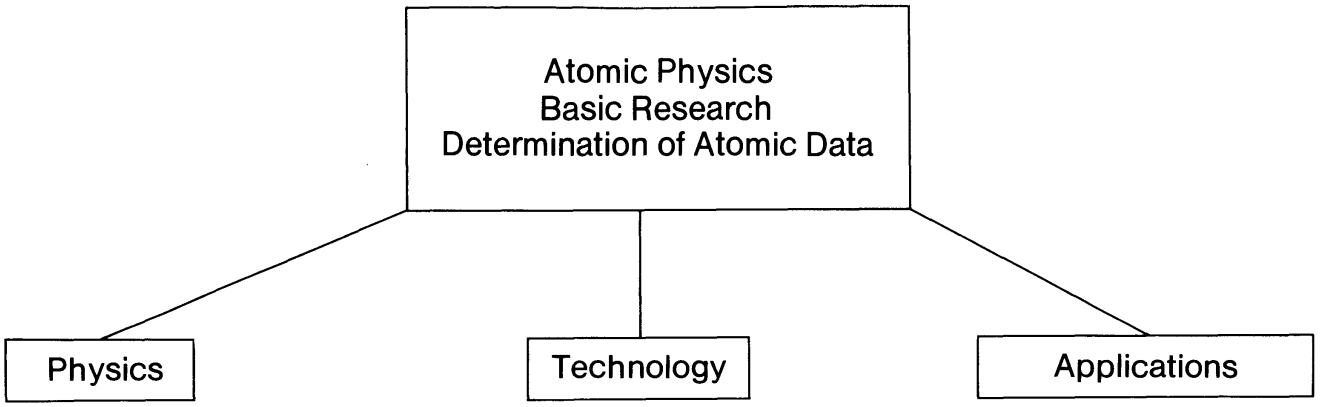
- ✓ 1885, Ordering principle in atomic spectra (J. Balmer)
- ✓ 1900, The laws of black body radiation (M. Plank)
- ✓ 1911, Planetary model of the atom (E. Rutherford)
- ✓ 1913, Bohr model for hydrogen
- ✓ 1925, Matter waves (De Broglie)
- ✓ 1926, Schroedinger equation (E. Schroedinger)
- ✓ 1928, Dirac equation (P. Dirac)

Solvay conference 1927



17 Nobel Prize winners! Niubility!

The application of atomic physics



Solid State Physics
Ideal and defect structures

Chemical Physics
Formation of molecules, chemical reactions

Astrophysics
Atomic spectroscopy

Plasma Physics
Excitation mechanisms

Biophysics
Complex molecular structures

Geophysics
Earth's magnetic field

Quantum Electronics
Lasers, frequency standards, navigation, geodetics

Medical Technology
Radiation effects

Communications Technology
Laser techniques, ionosphere

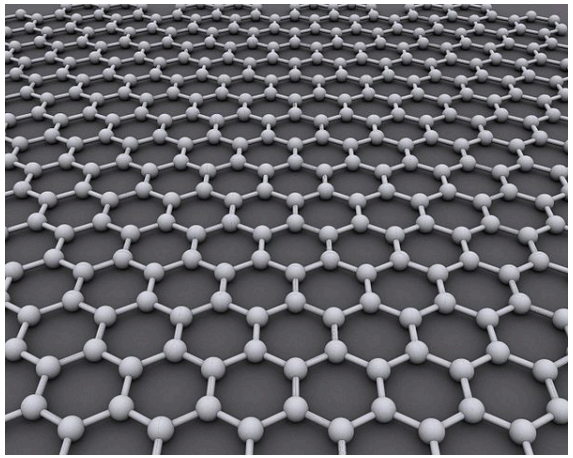
Determination of Units
Fundamental constants

Space Research
Earth and planetary atmospheres, weather

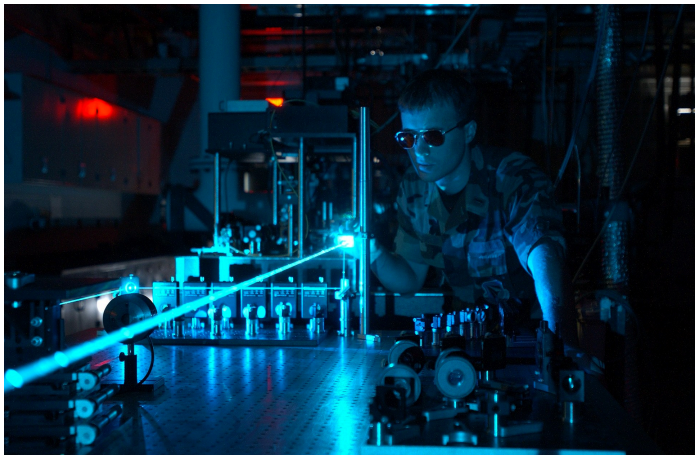
Environment
Detection of pollutants

Energy Problems
New methods of energy production

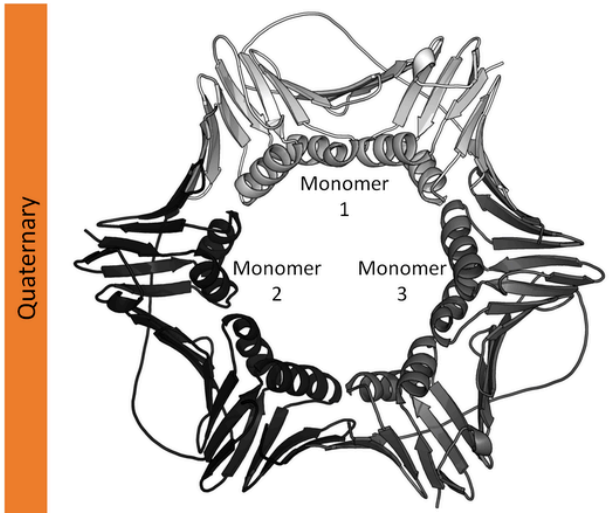
The application of atomic physics



Graphene



Laser



Biomolecular structure

CT Scan

Class outline

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- ✓ Introduction (2 classes)
- ✓ Basic Properties of Atom (4 classes)
- ✓ Bohr's Model of the Hydrogen Atom (6 classes)
- ✓ Quantum Mechanics of the Hydrogen Atom (8 classes)
- ✓ Fine structures of Atoms (8 classes)
- ✓ Many-Electron Atoms (8 classes)
- ✓ X-Ray (8 classes)
- ✓ Nuclear physics (4 classes)