

核能与核武器：一步之遥

狄增峰

中国科学院上海微系统与信息技术研究所

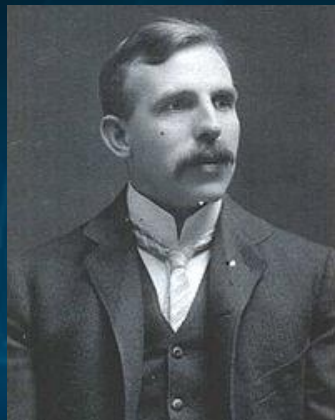
提纲

- 核能的物理奥秘
- 核能的利用
- 核能与核武器
- 核扩散限制

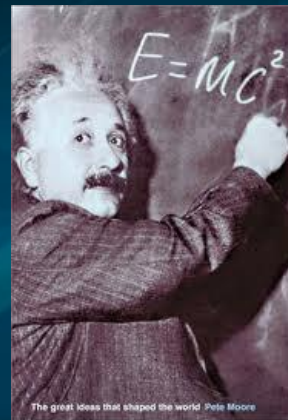
核能的发现



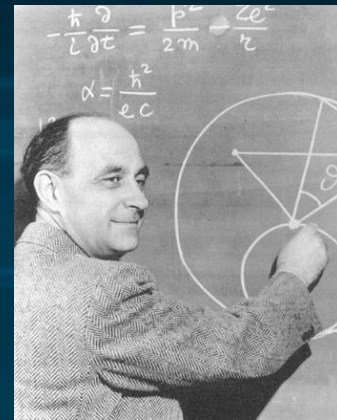
1898年，居里夫妇发现放射性镭



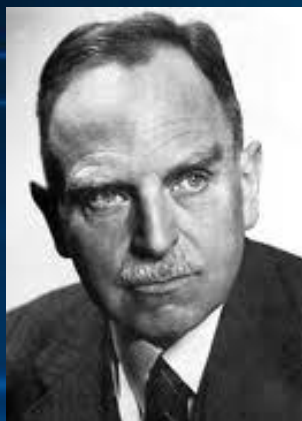
1904年，卢瑟福提出质量能量关联



1905年，爱因斯坦提出质能方程



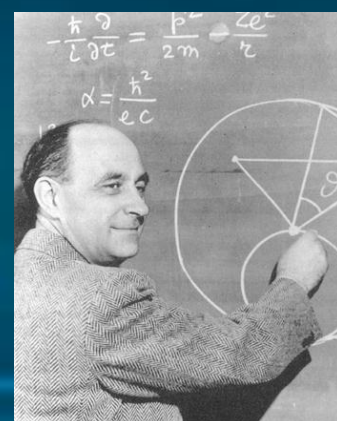
1934年，费米发现中子可以实现原子分裂



1938年，Hahn-Strassman-Meitner发现中子可以分裂铀，并出现质量损失

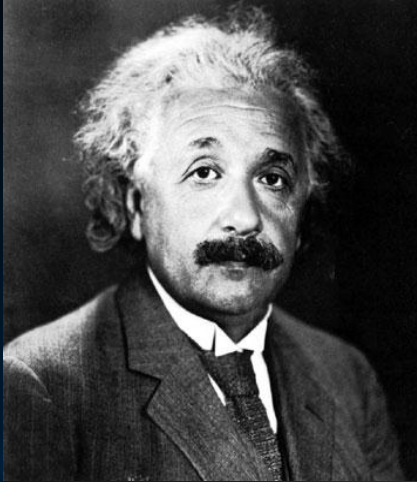


1941年，Leo Szilard提出链式反应模型



1942年，费米在芝加哥大学主持实现核反应堆

核能的发现（续）



F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

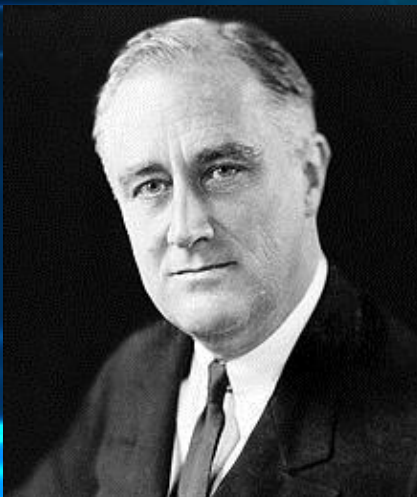
August 2nd, 1939

Sir:

Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.



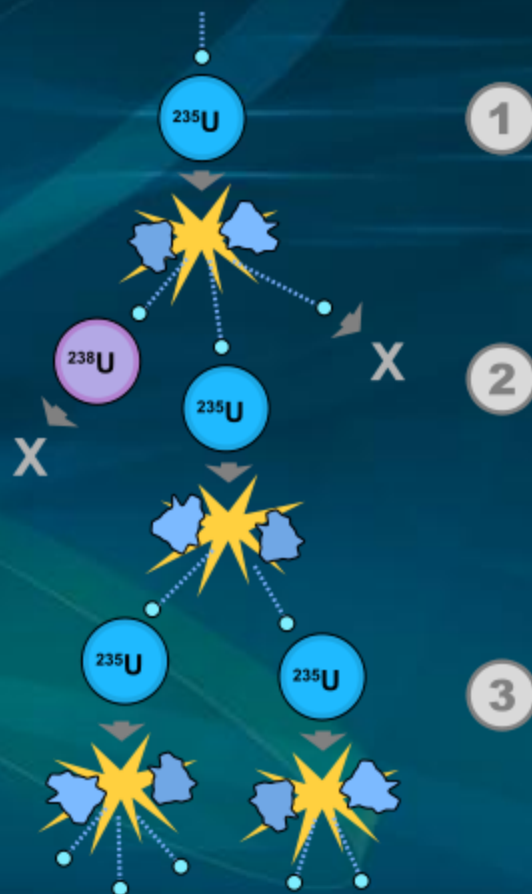
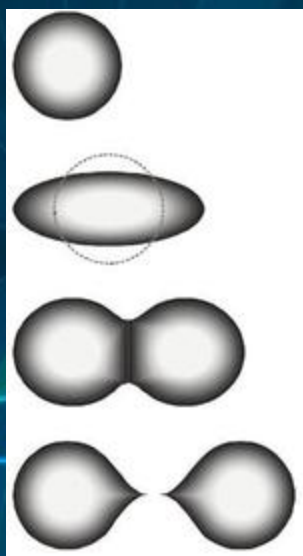
小测试

- 世界上第一颗原子弹的名字
 - “瘦子”
 - “小男孩”
 - “胖子”

小测试

- 世界上第一颗原子弹的名字
 - ✓ “瘦子”
 - “小男孩”
 - “胖子”

核能的物理奥秘



$$\Delta E = \Delta m c^2$$

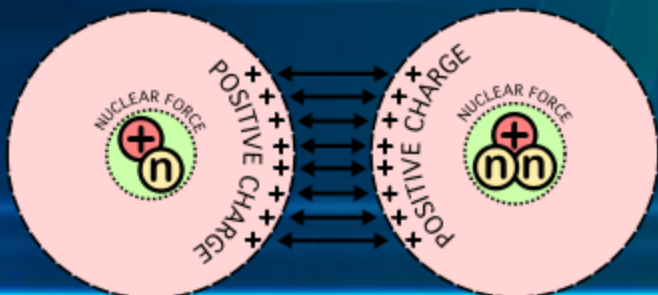
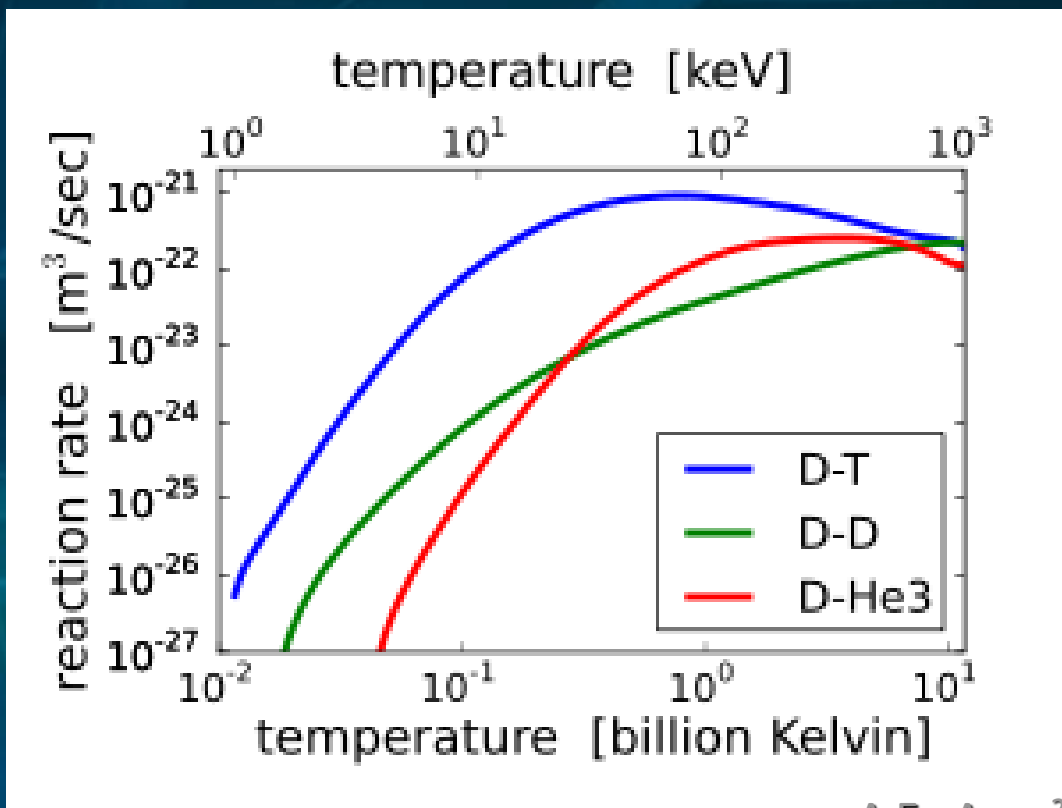
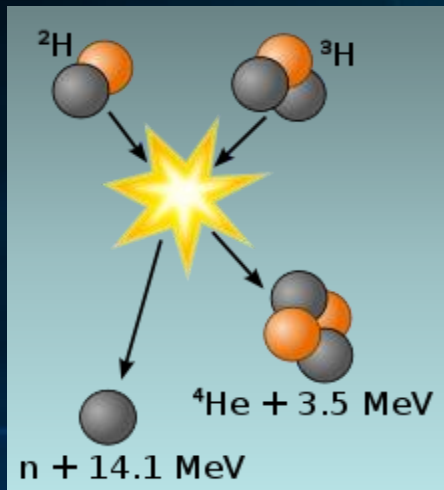
$$= [\text{反应物质量} - \text{生成物质量}] c^2$$

$$= [m(\text{U-235}) + m_n - m(\text{Ba-141}) - m(\text{Kr-92}) - 3m_n] c^2$$

$$= [235.043915 + 1.008665 - 140.0130 - 91.8973 - 3(1.008665)] (931.494 \text{ MeV}/c^2) c^2$$

$$= 201 \text{ MeV}$$

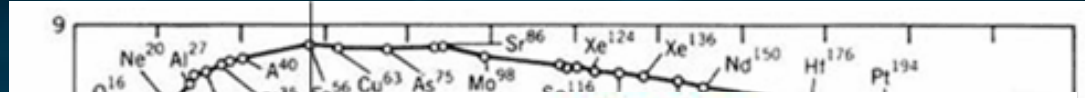
核能的物理奥秘



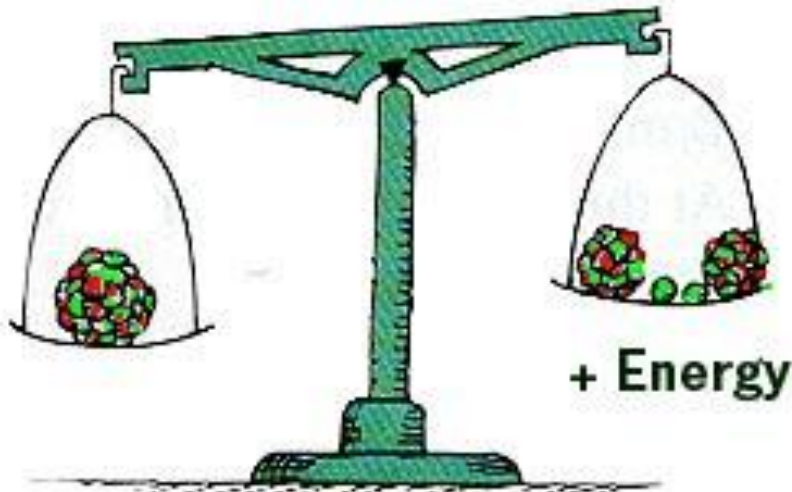
$$\begin{aligned}
 \Delta E &= \Delta m c^2 \\
 &= [\text{反应物质量} - \text{生成物质量}] c^2 \\
 &= [m(\text{D-2}) + m(\text{T-3}) - m(\text{He-4}) - m_n] c^2 \\
 &= [2.01410 + 3.01605 - 4.00260 - 1.008665] (931.494 \text{ MeV}/c^2) c^2 \\
 &= 17.6 \text{ MeV}
 \end{aligned}$$

核能的物理奥秘

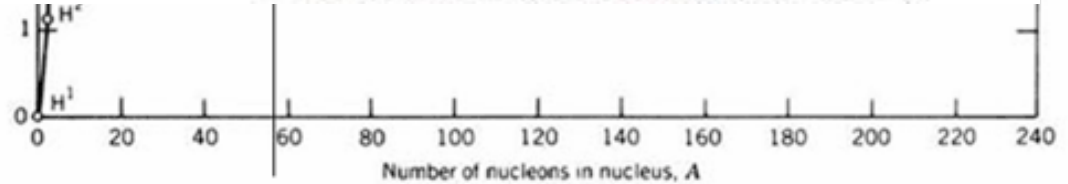
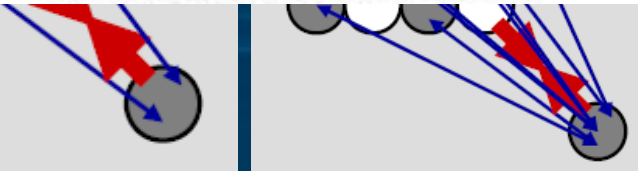
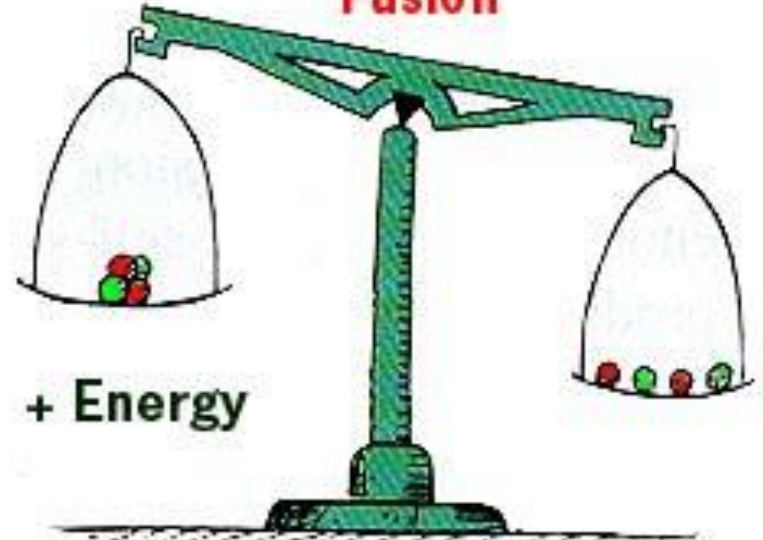
FORCE ↑
ATTRACTION



Fission



Fusion



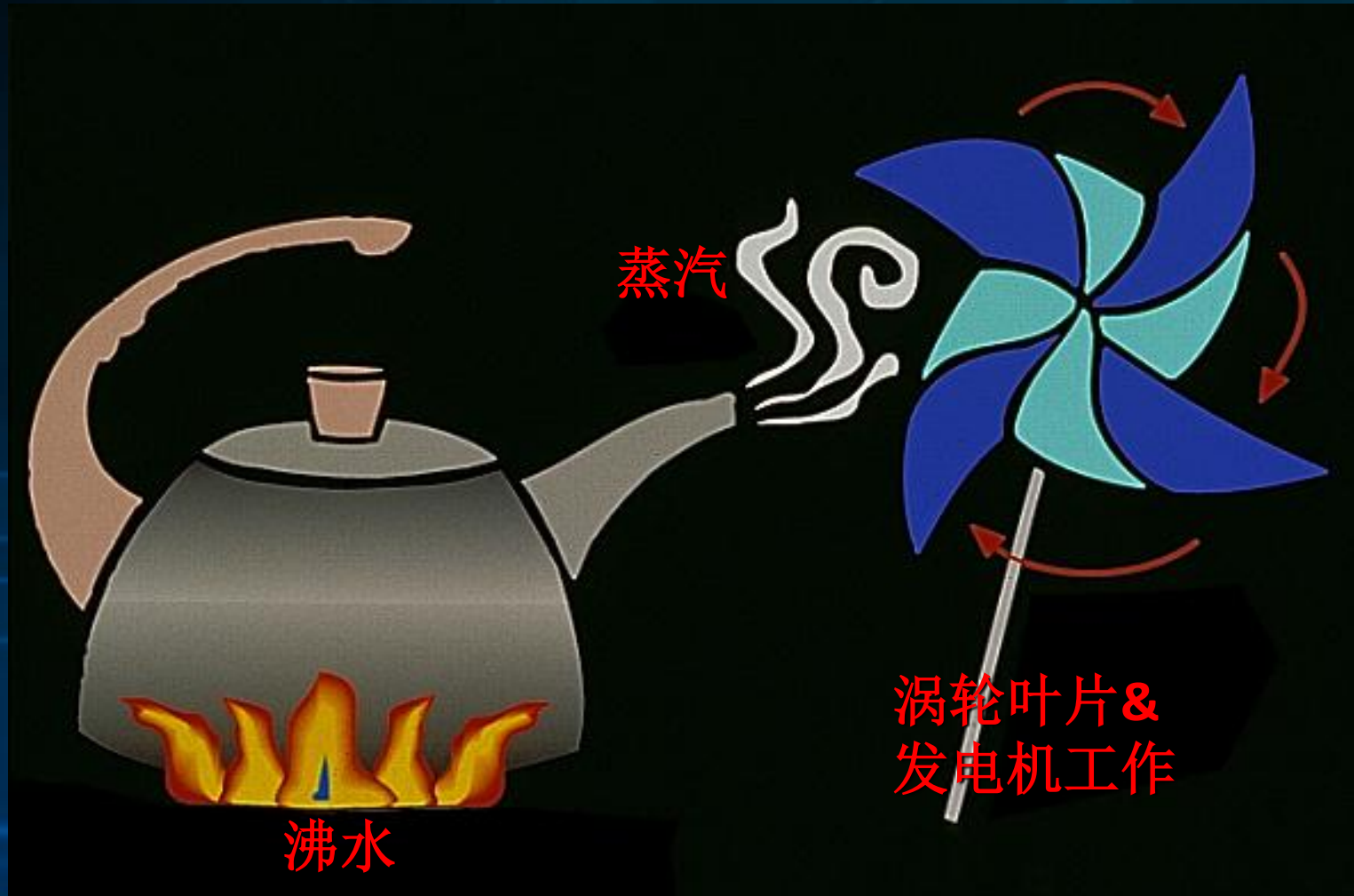
小测试

- 核裂变包括哪个过程
 - 强迫原子高速震动
 - 两个小原子合并为大原子
 - 使用中子轰击原子的原子核

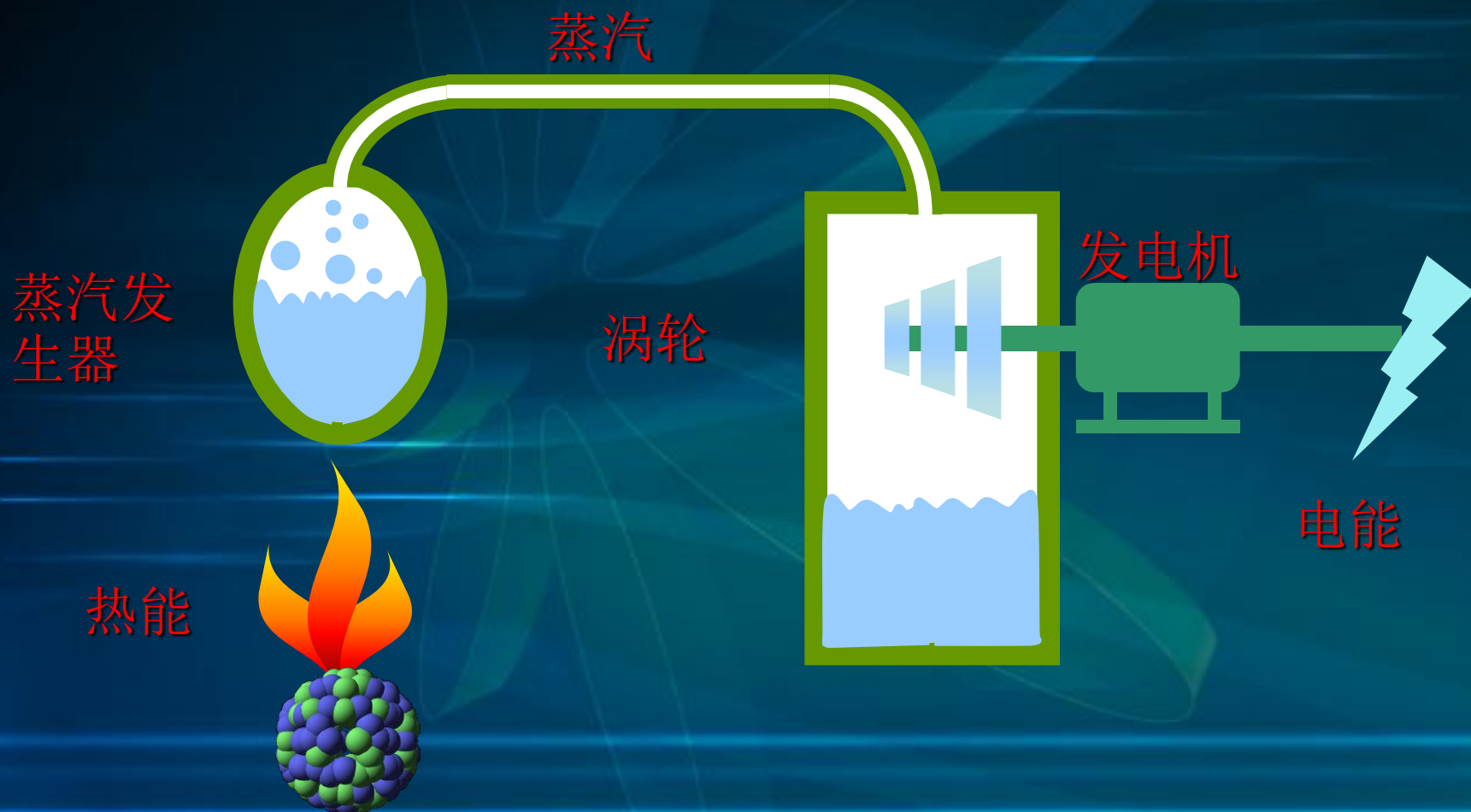
小测试

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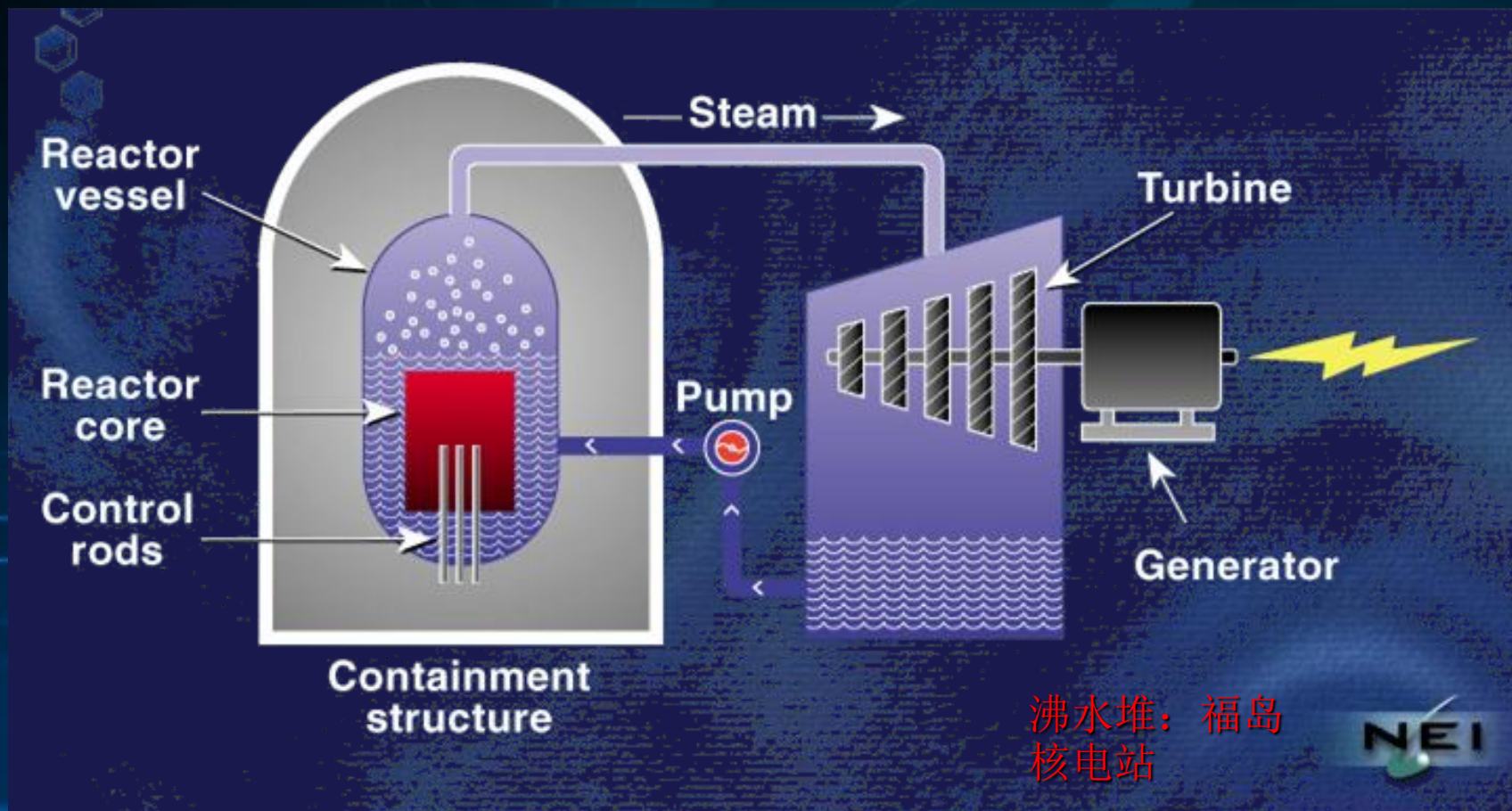
核能的利用



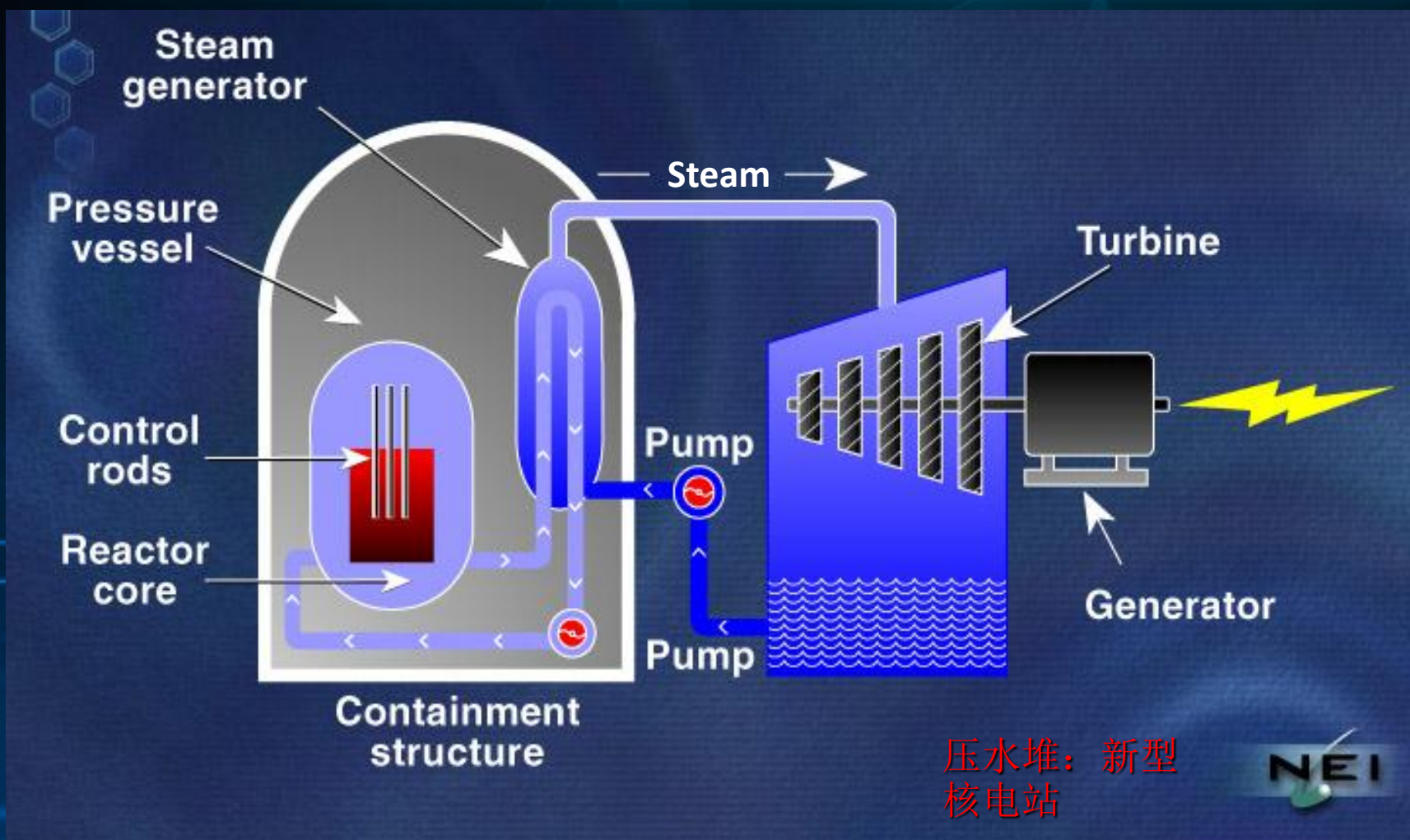
核能的利用



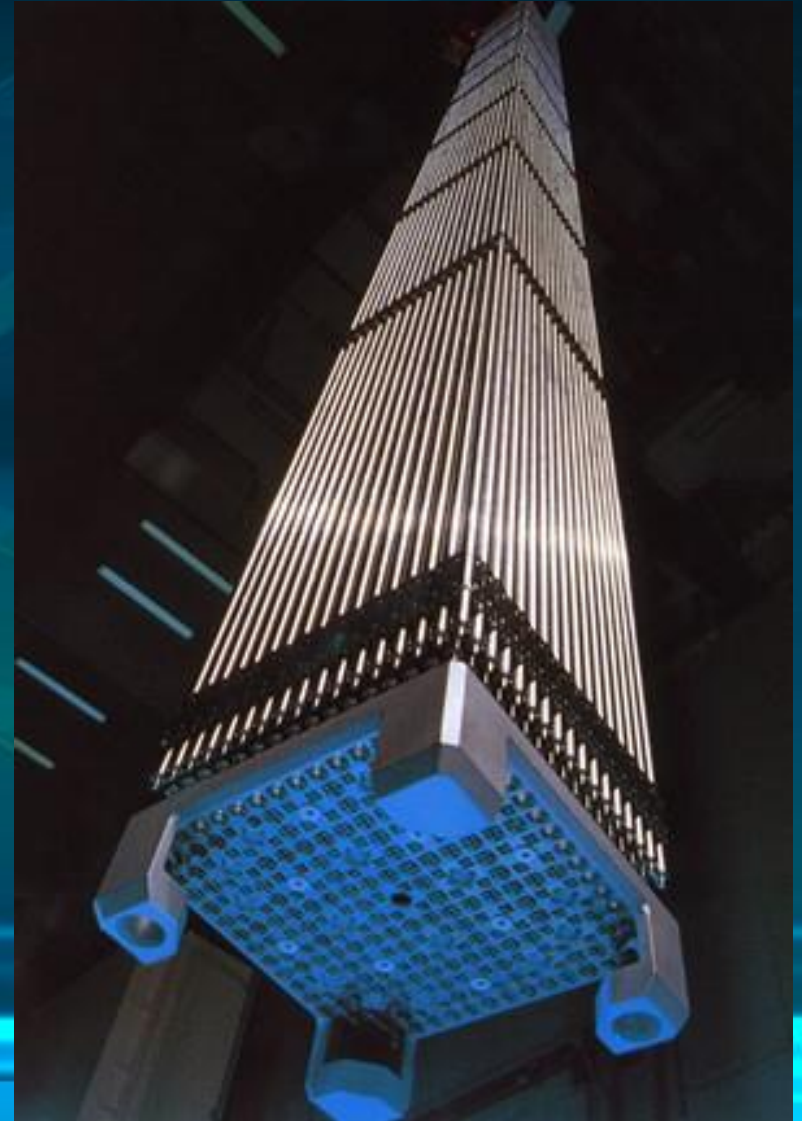
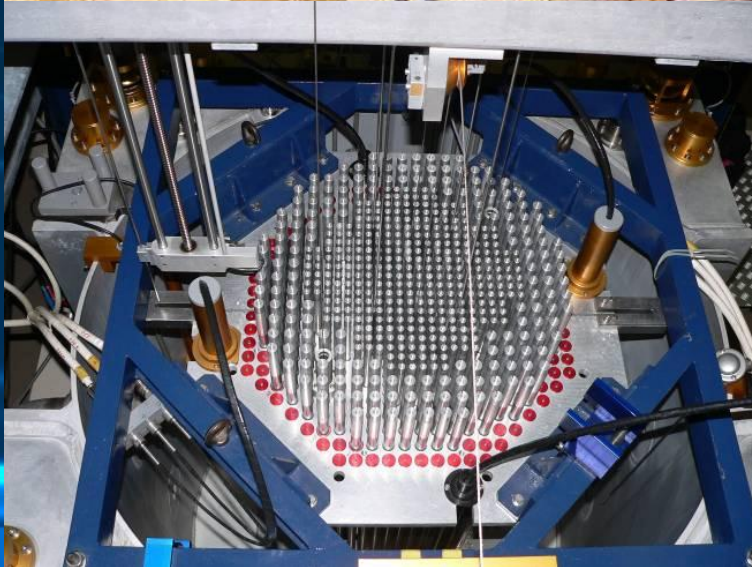
核能的利用



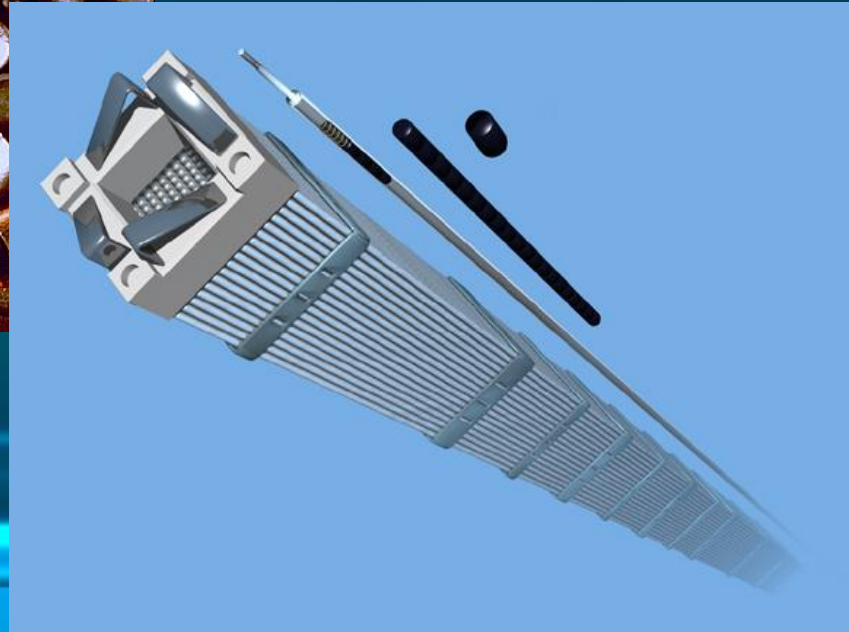
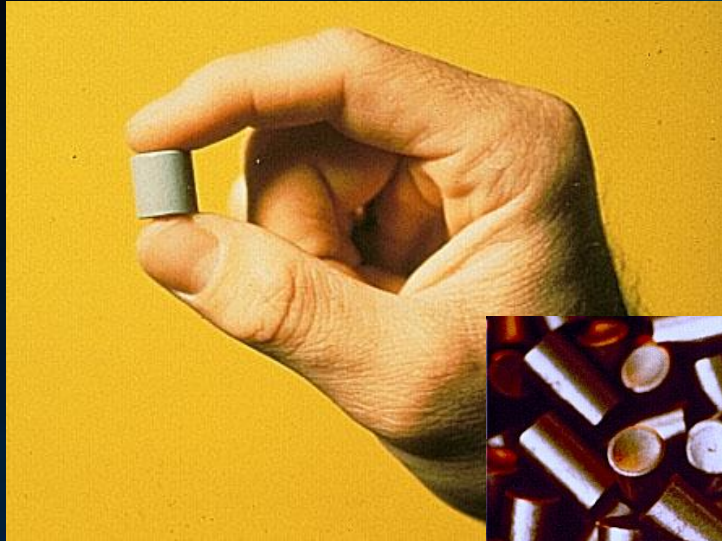
核能的利用



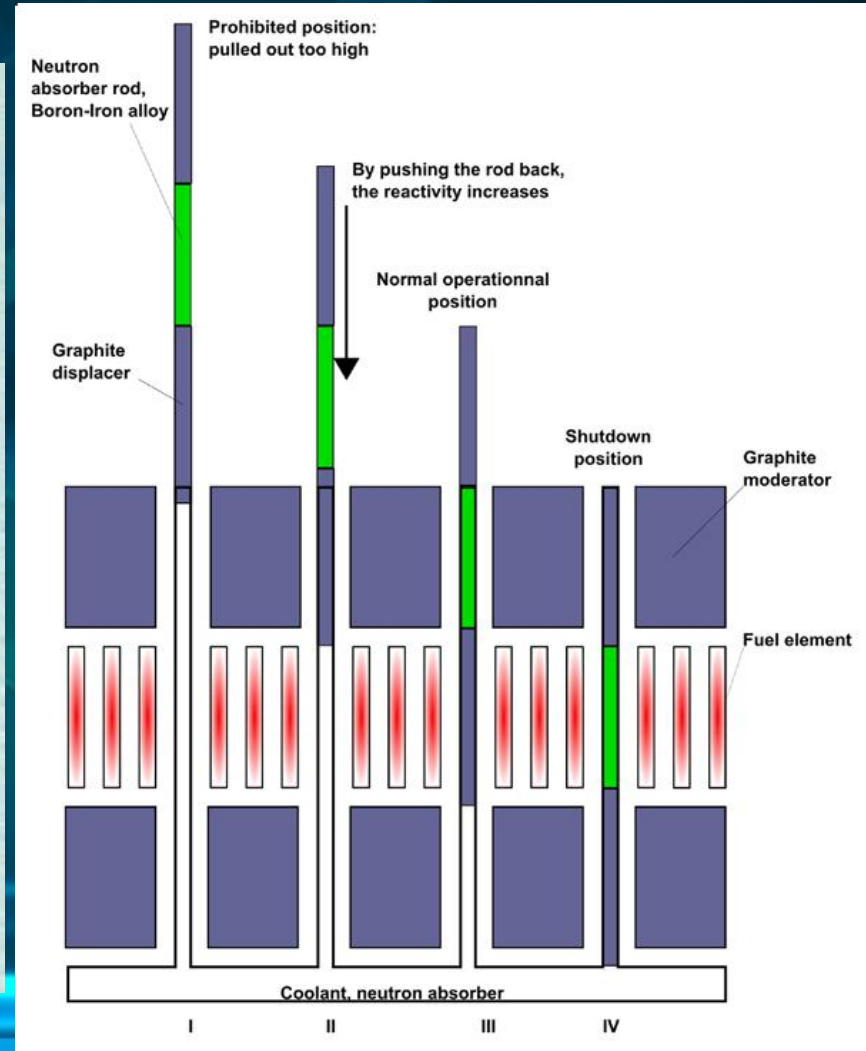
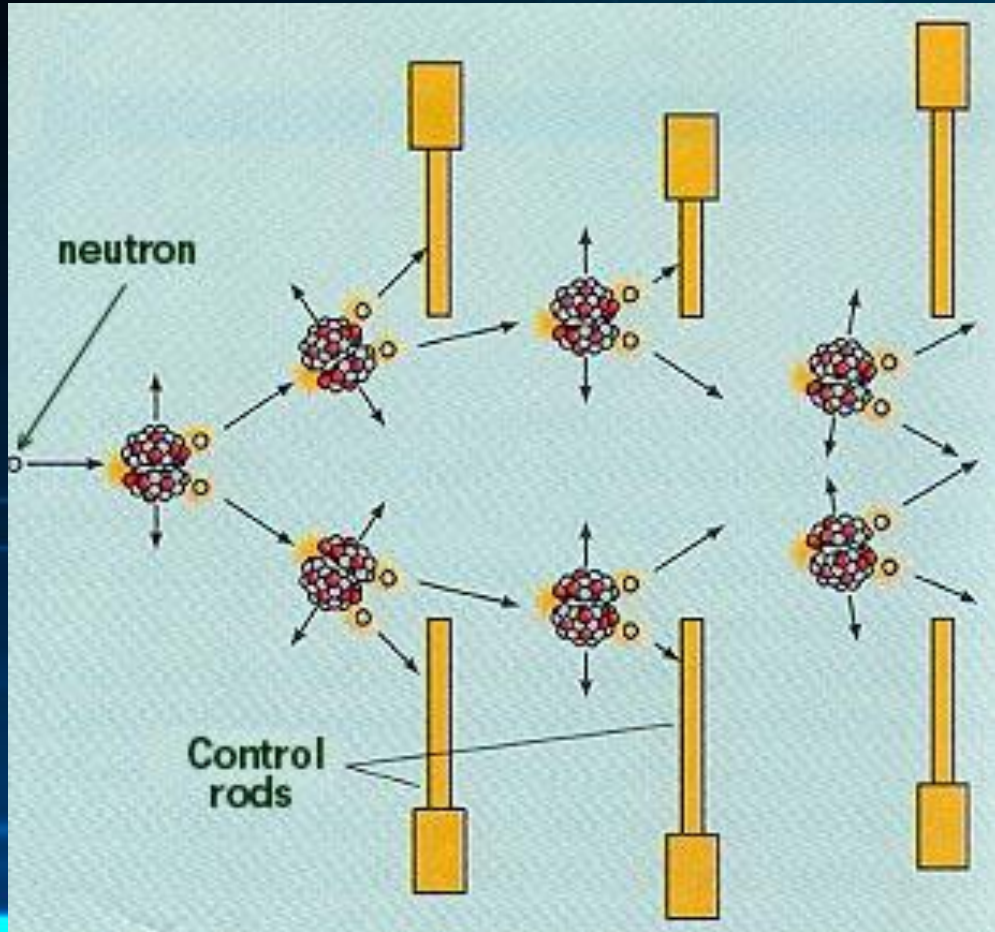
核能的利用



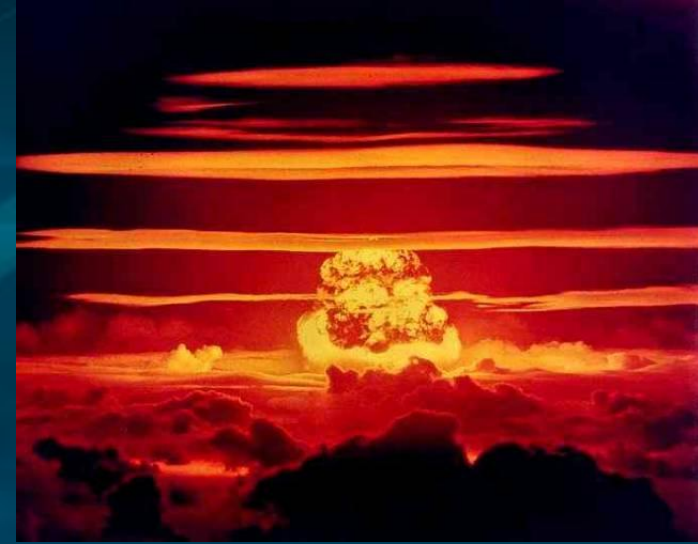
核能的利用



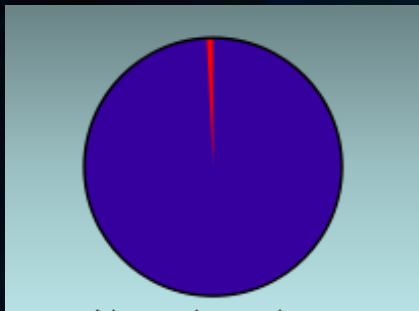
核能的利用



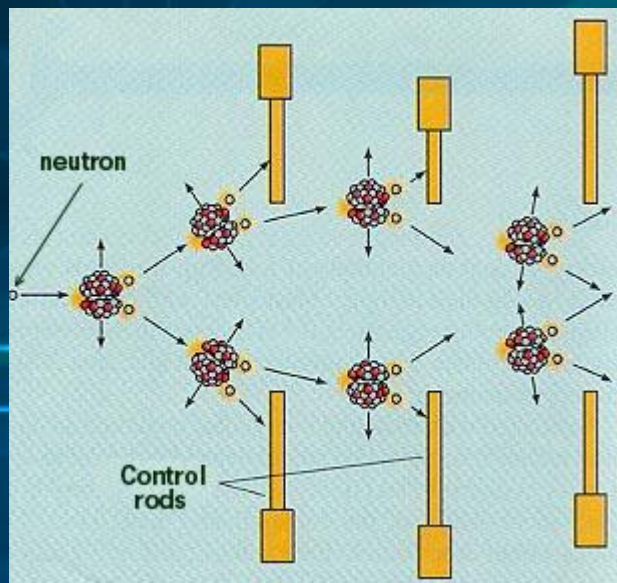
核能与核武器



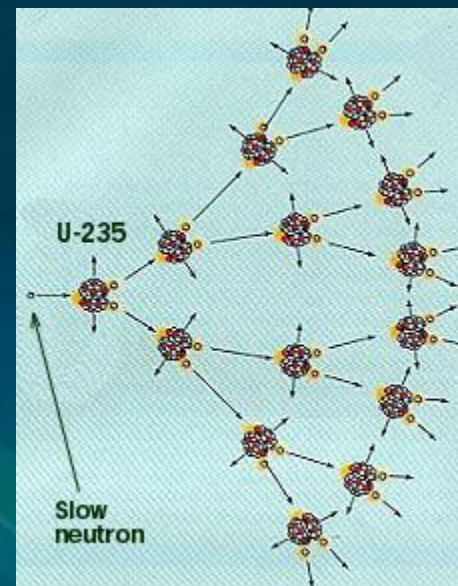
核能与核武器



自然铀矿
>99.2% 铀238
0.72% 铀235

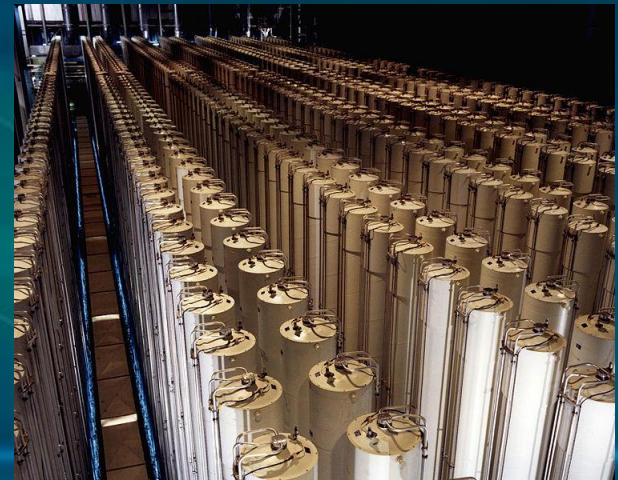
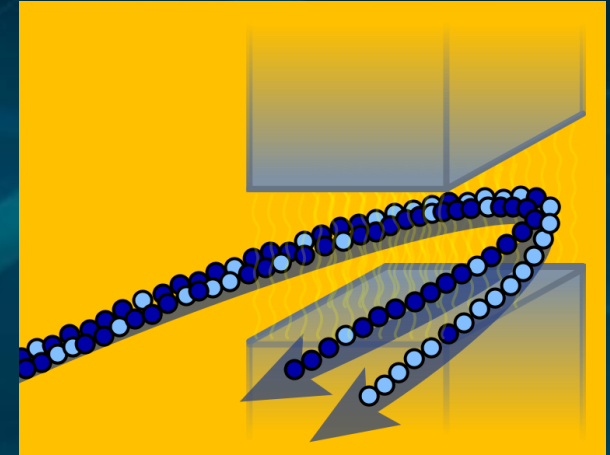
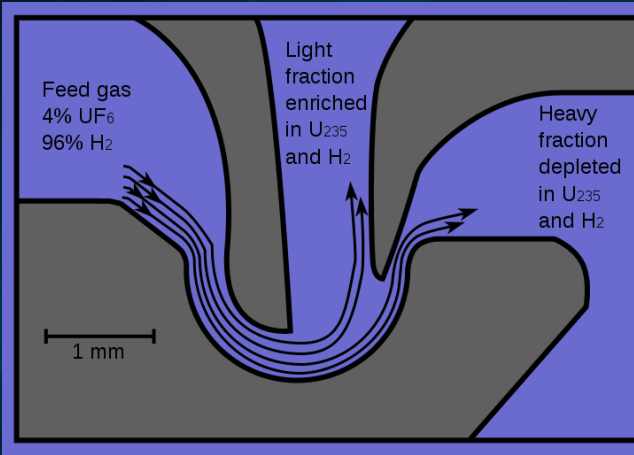
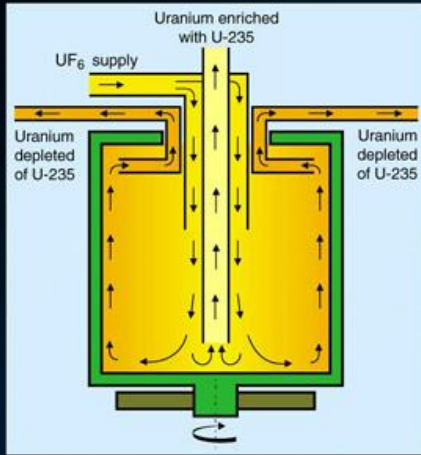


低浓缩铀
(反应堆级)
3-4% 铀235

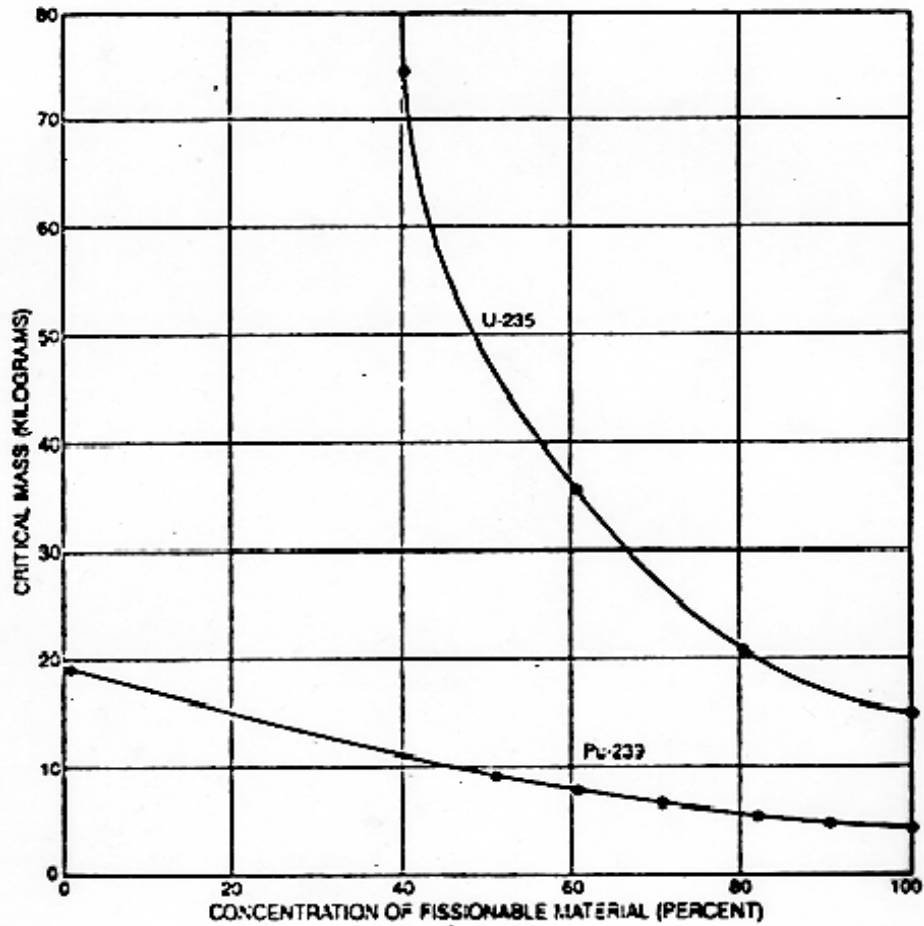


高浓缩铀
(核武器级)
90% 铀235

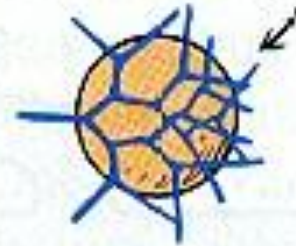
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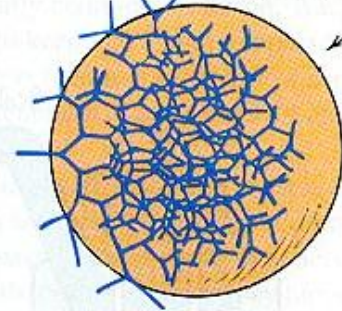
核能与核武器



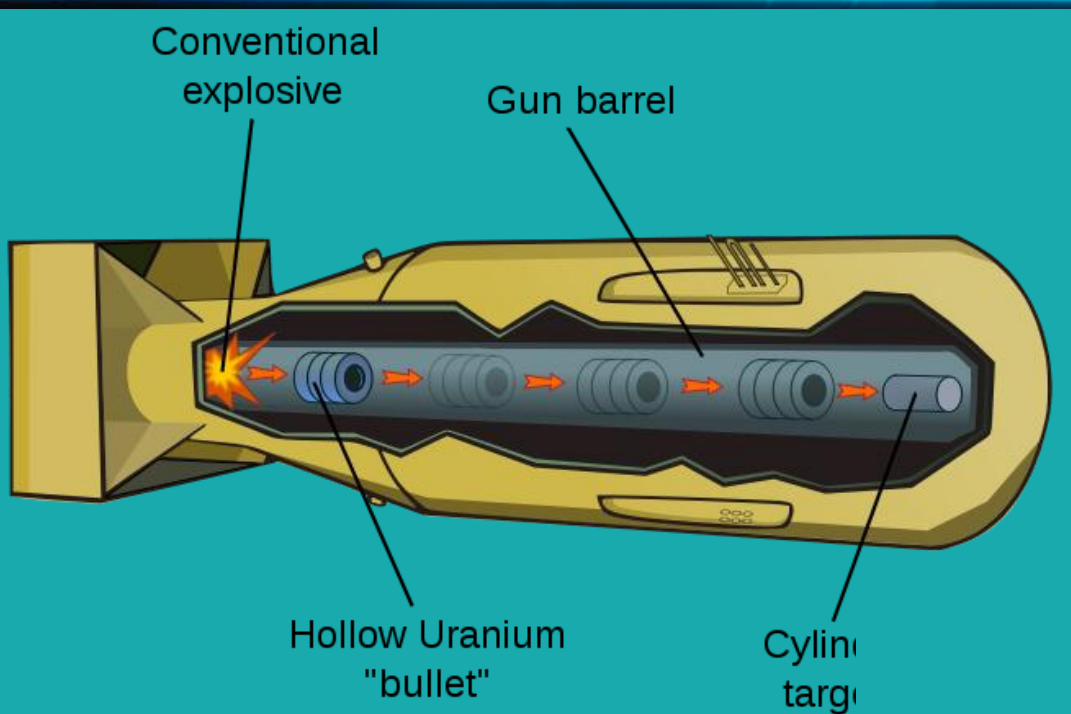
Neutrons escape surface



Neutrons trigger more reactions

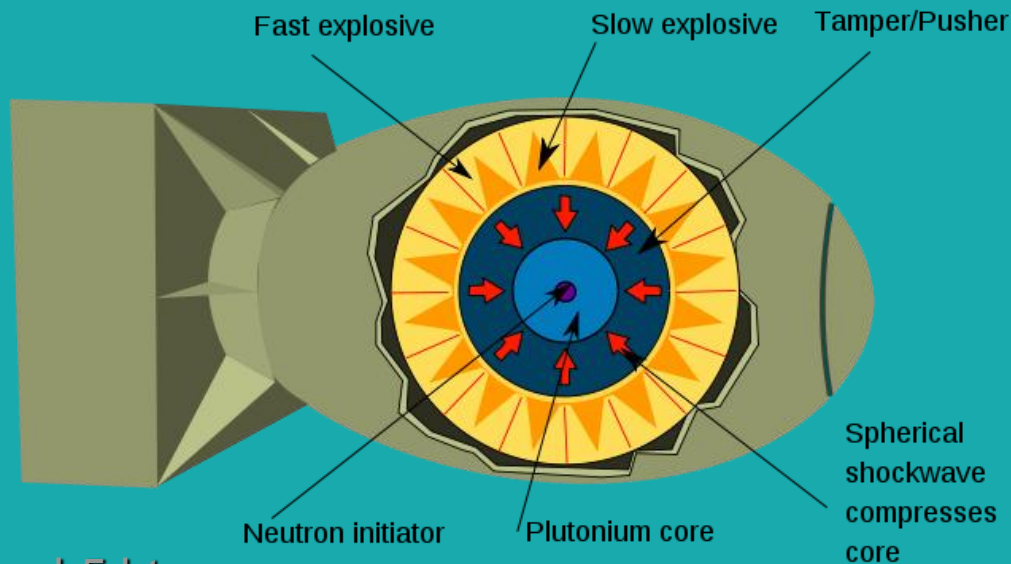


核能与核武器



枪式核弹：小男孩

内爆式核弹：胖子



小测试

- “小男孩”是那种类型核弹
 - 枪型诱发裂变式
 - 内爆诱发裂变式
 - “泰勒-乌拉姆”聚变式

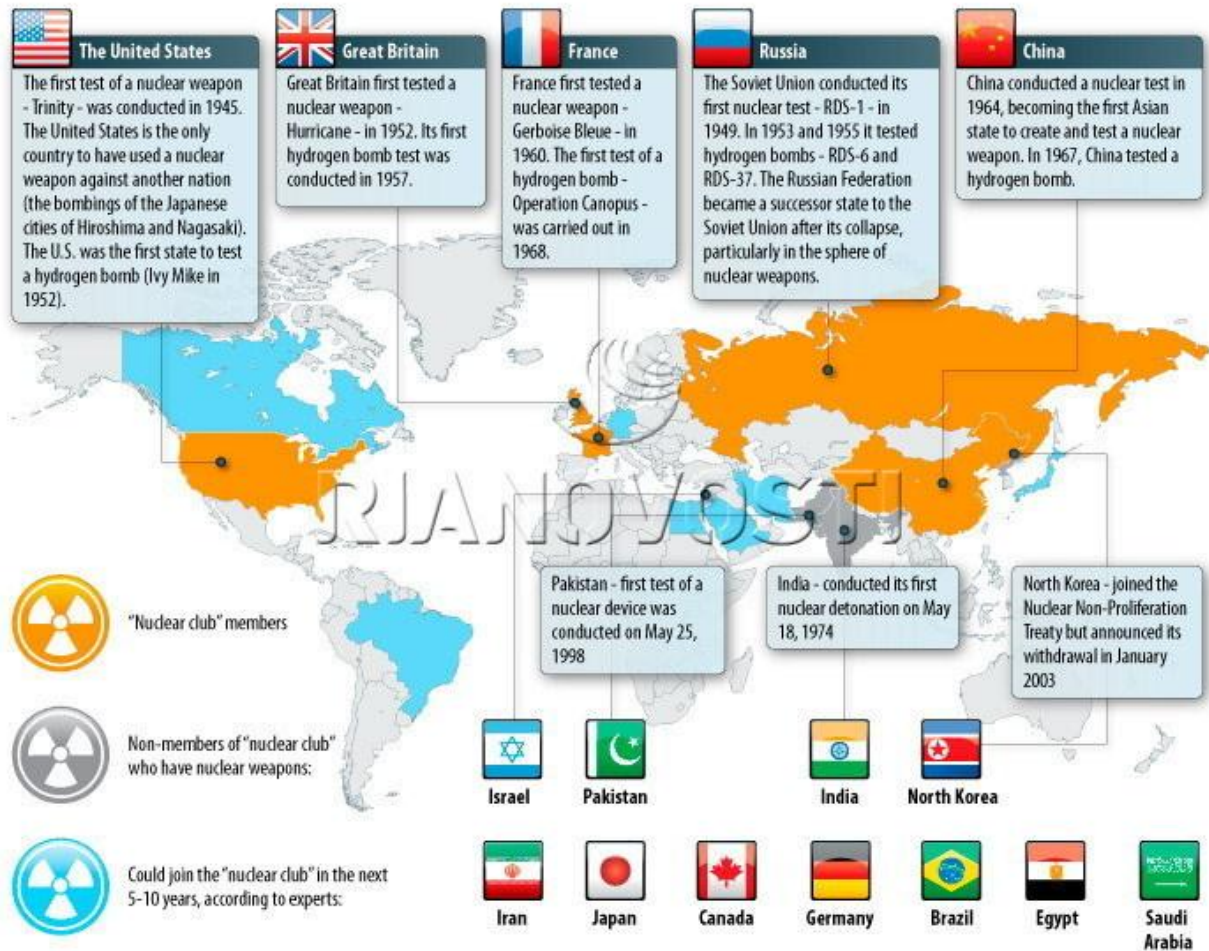
小测试

- “小男孩”是那种类型核弹
 - ✓ 枪型促发裂变式
 - 内爆促发裂变式
 - “泰勒-乌拉姆”聚变式

核扩散限制

World's nuclear states map

Under the Nuclear Non-Proliferation Treaty (NPT), a nuclear state is defined as one that detonated a nuclear device prior to January 1, 1967.



核扩散限制



核弹 核俱乐部

签署不扩散核武器条约的国家(中国, 法国, 俄罗斯英国, 美国)

未签署不扩散核武器条约的国家(印度, 北朝鲜, 巴基斯坦)

未公开核武器的国家(以色列)

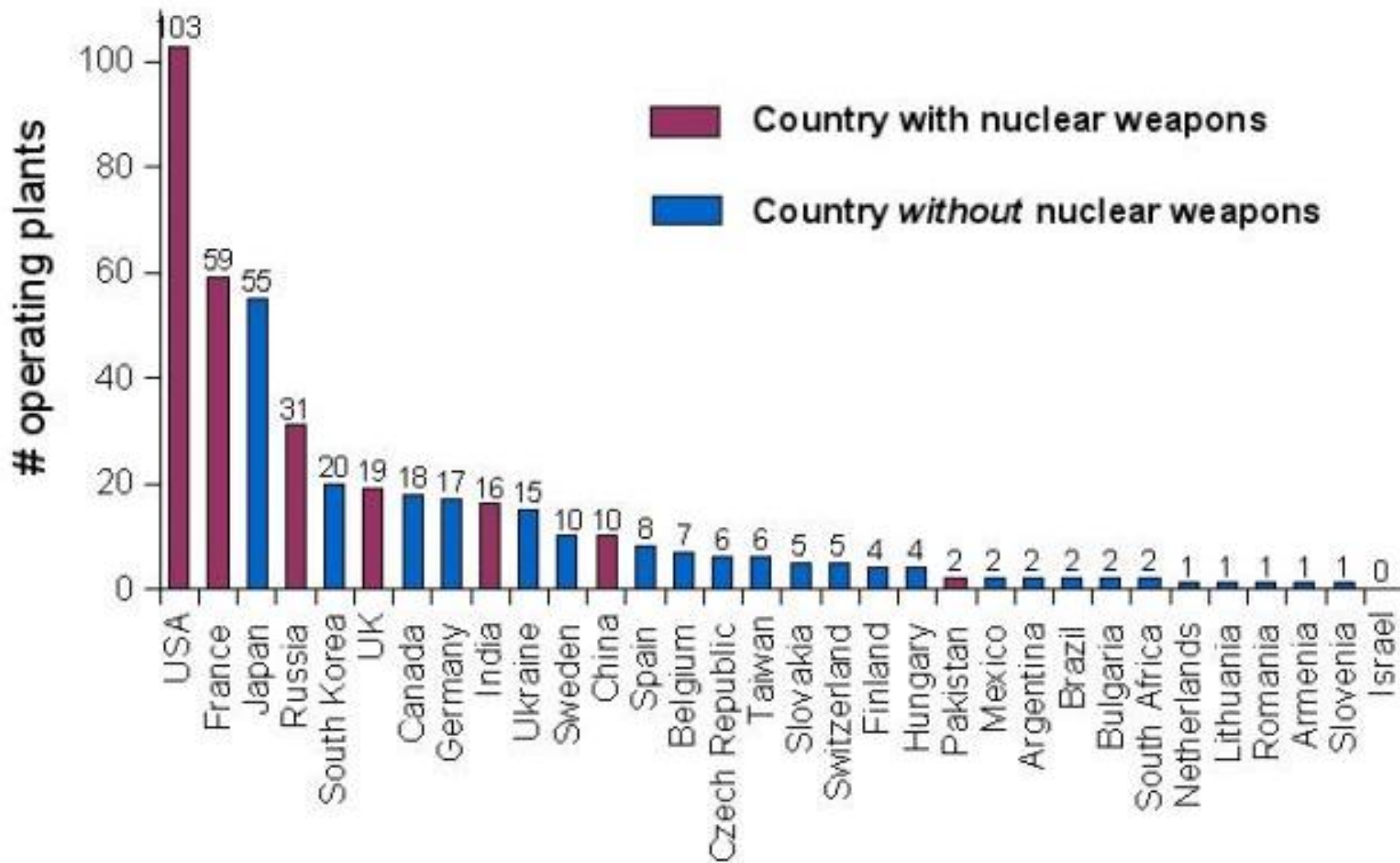
被怀疑拥有核武器或核计划的国家(伊朗, 叙利亚)

北约武器共享与接受

正式拥有核武器的国家



核扩散限制



核扩散限制



153 国家

国际原子能机构：守在人类希望的最边缘

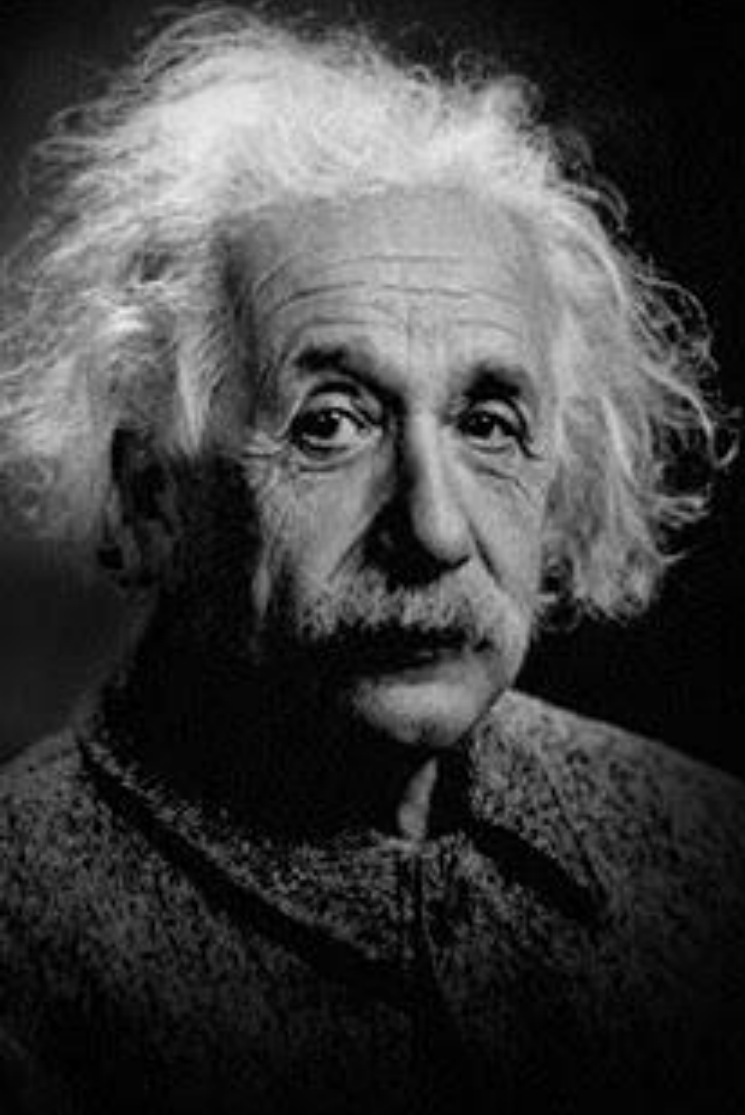
小测试

- 全世界有多少座核电站
 - 几十
 - 几百
 - 几千

小测试

- 全世界有多少座核电站
 - 几十
 - 几百
 - 几千

结语



I made one of the worst mistakes in my life... when I signed the letter to President Roosevelt recommending that atom bombs be made, but there was some justification-the danger that the Germans would make them
-Albert Einstein