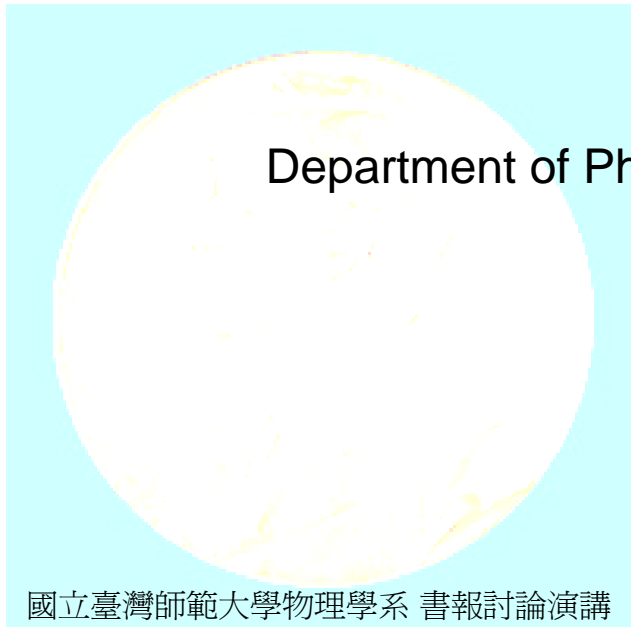




Alfred Nobel Prize in Chemistry 2007



J.S. Tsay

Department of Physics, National Taiwan Normal University, Taipei

24, Oct. 2007

The Nobel Prize in Chemistry 2007

"for his studies of chemical processes on solid surfaces"



Gerhard Ertl

Germany

Fritz-Haber-Institut
der Max-Planck-Gesellschaft
Berlin, Germany

b. 1936



The Nobel Prize in Physics 1918

"in recognition of the services he rendered to the advancement of Physics by his discovery of **energy quanta**"



Max Karl Ernst Ludwig Planck

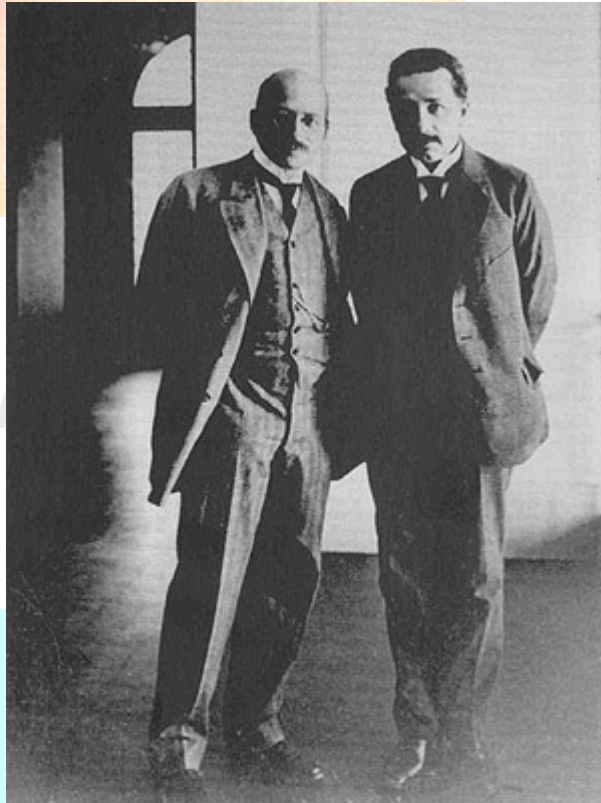
Germany

Berlin University
Berlin, Germany

b. 1858
d. 1947

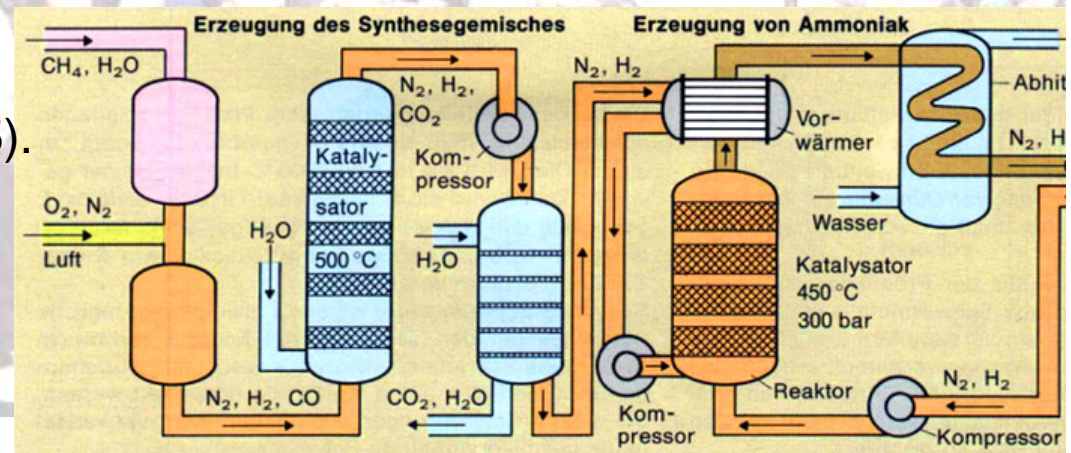
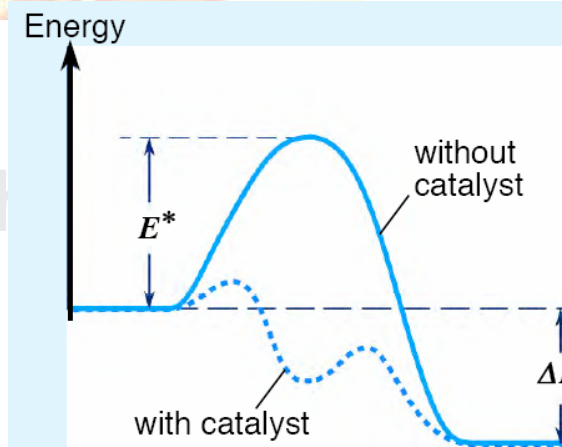
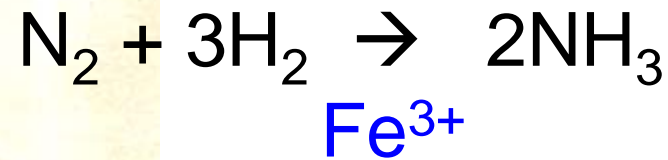


Haber Process, (Haber-Bosch process or Fritz-Haber Process)



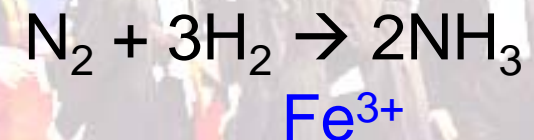
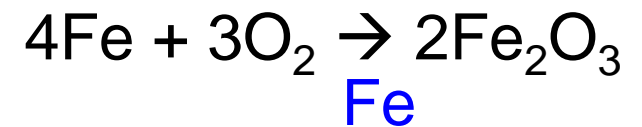
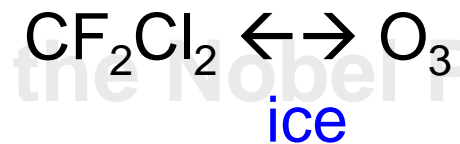
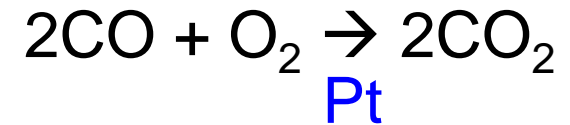
Fritz Haber (left) and Albert Einstein (right) at the "Fritz-Haber-Institut" (1915).

The Nobel Prize in Chemistry 1918



NP in Chemistry 2007 - Chemical processes on solid surfaces

From artificial fertilizers to clean exhaust



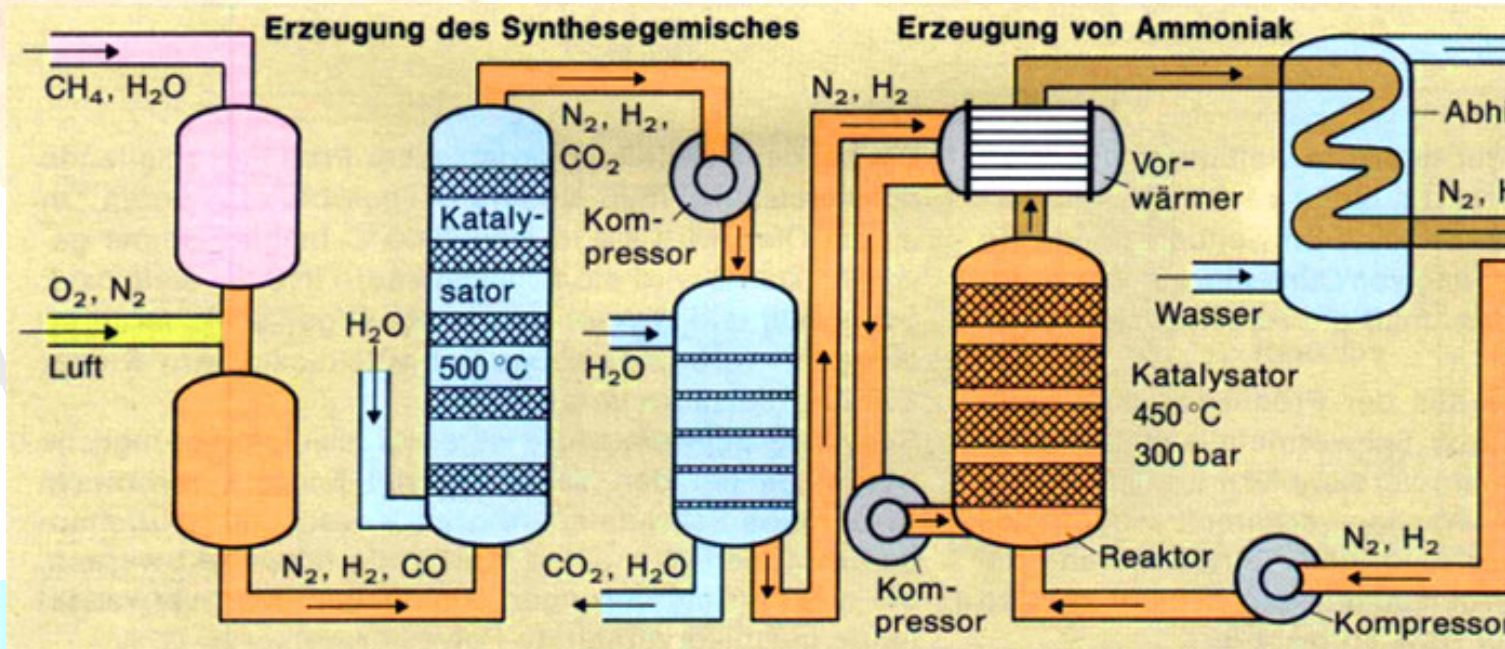
Achievement - Gerhard Ertl

Nobel Prize for having laid the **methodological foundations** for an entire field of surface chemistry.

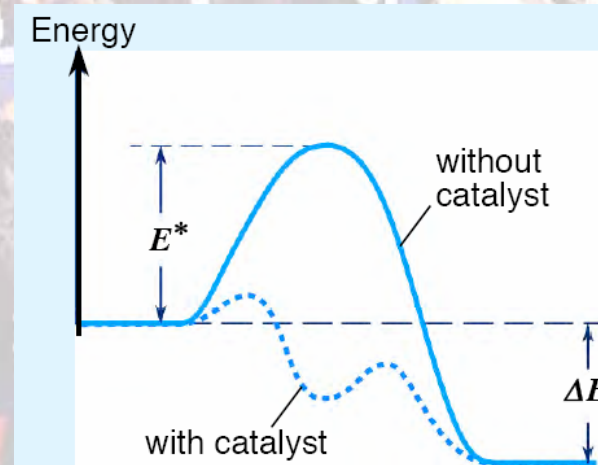
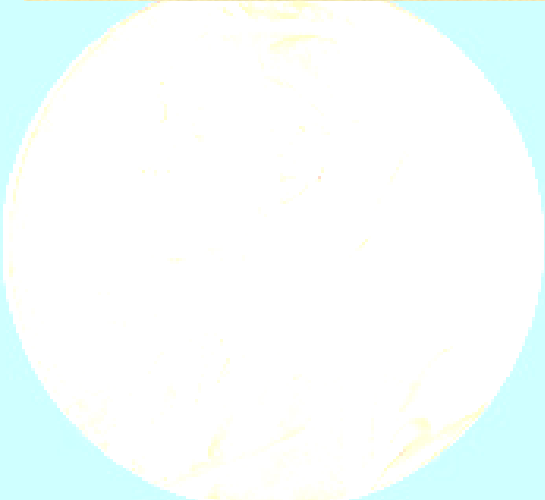
He has painstakingly and systematically searched for the **best experimental techniques** to investigate each separate question.



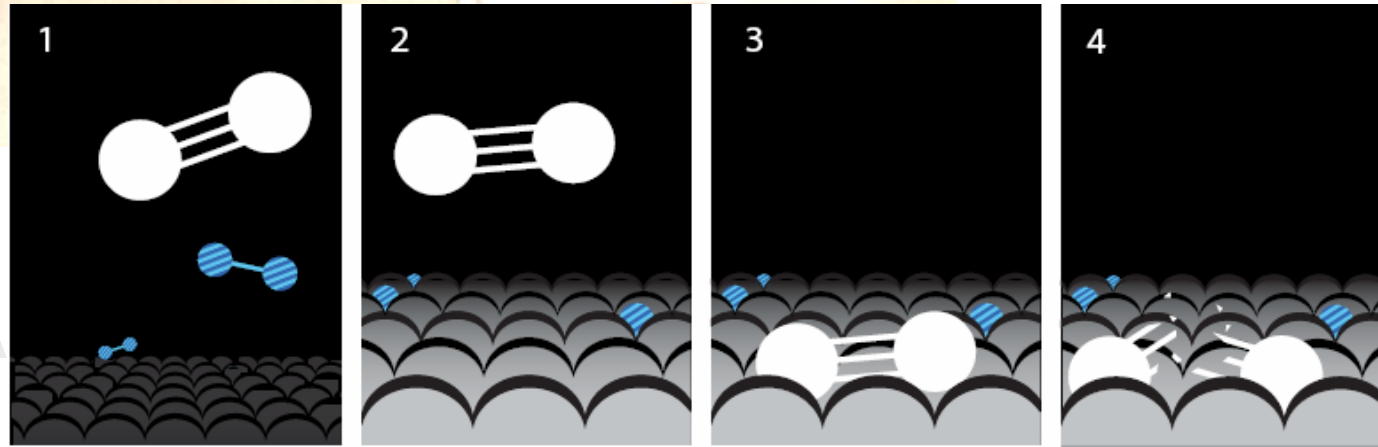
The Haber-Bosch process



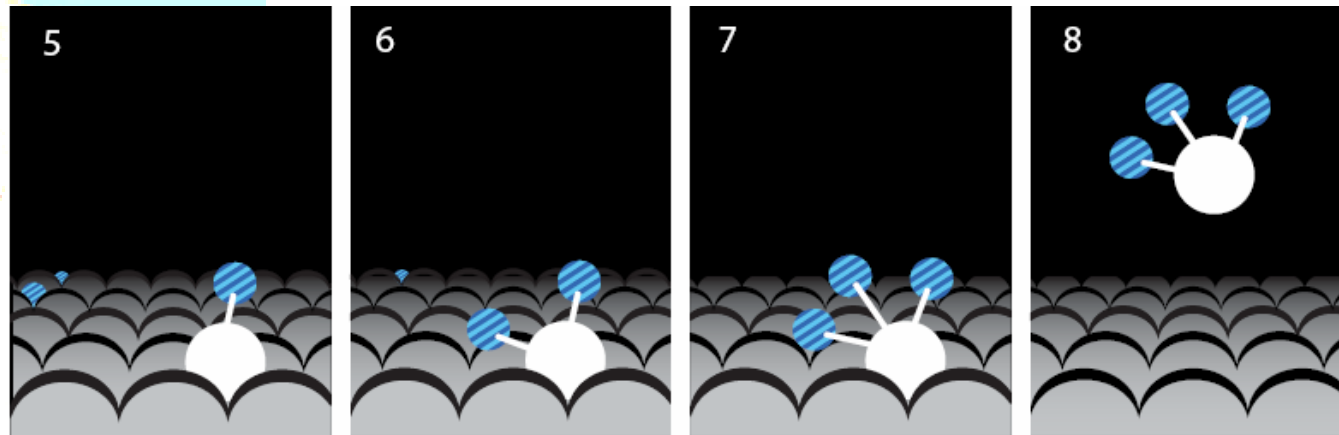
Nobel Prize



The Haber-Bosch process step-by-step

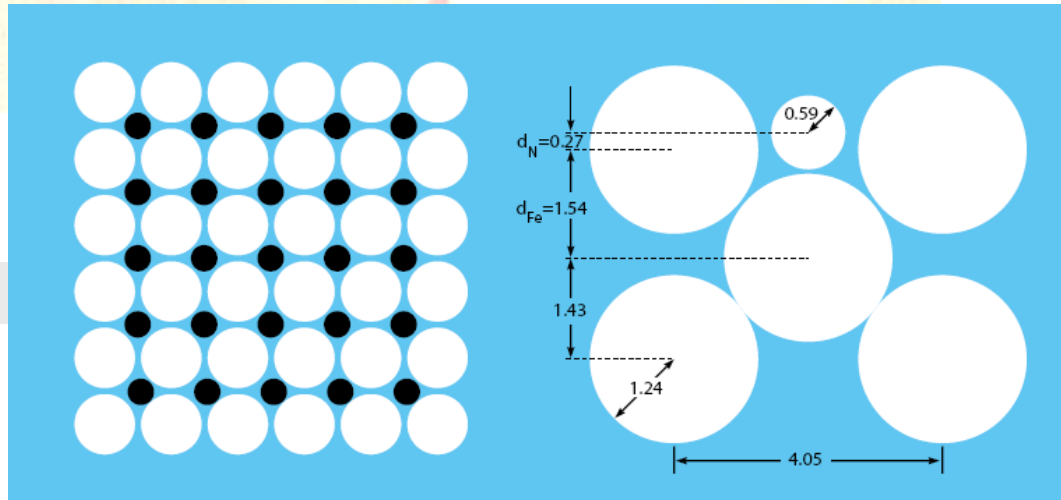


Nitrogen split takes longest.



The Haber-Bosch process step-by-step

Determination of adsorbate structures

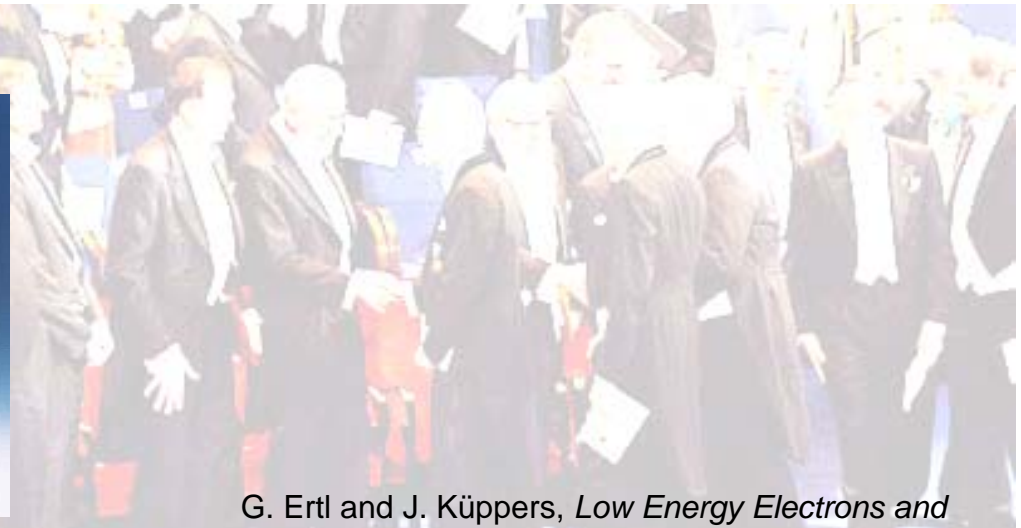


N/Fe(100)

N/Fe(110)

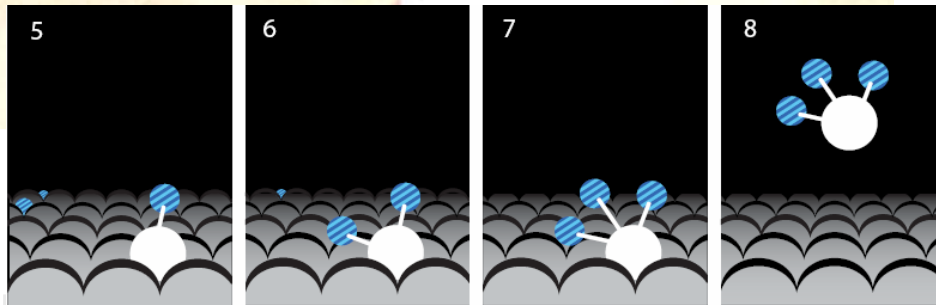
N/Fe(111)

LEED

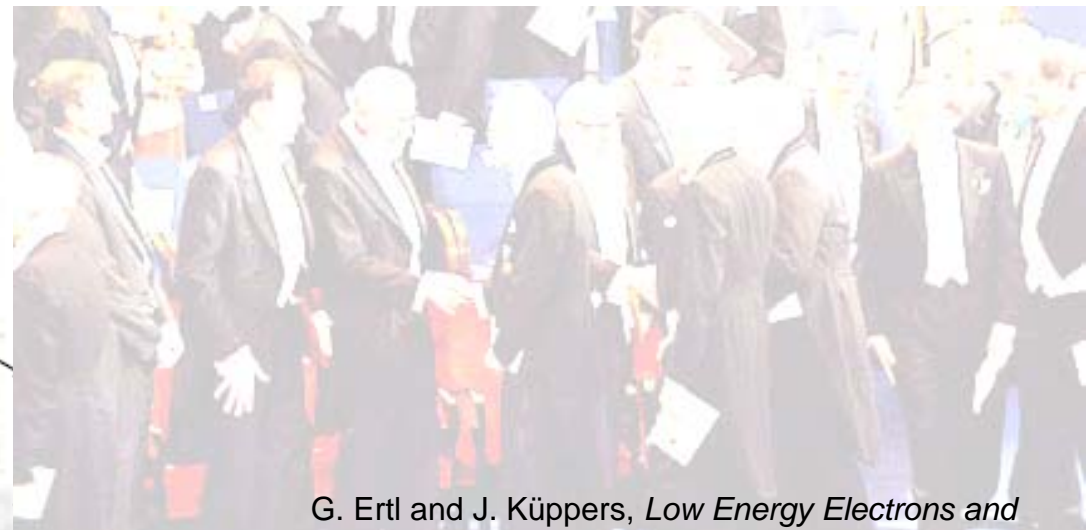
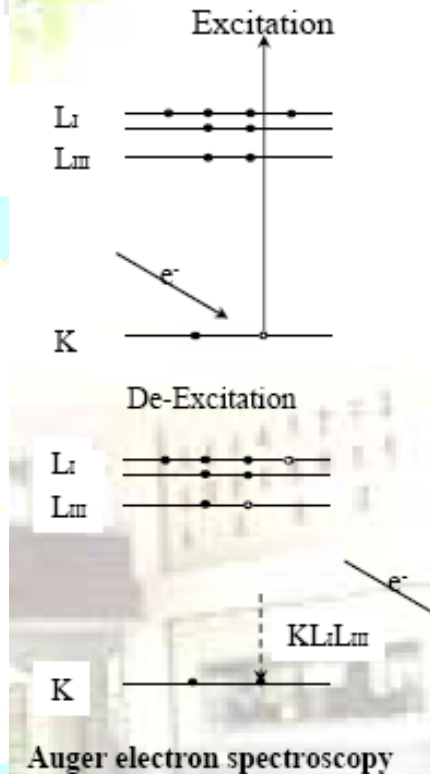


The Haber-Bosch process step-by-step

Determination of nitrogen coverage versus H₂ pressure



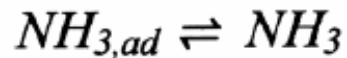
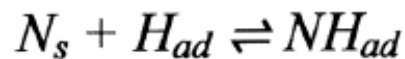
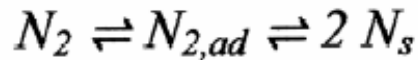
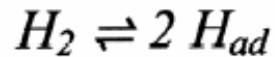
AES



G. Ertl and J. Küppers, *Low Energy Electrons and Surface Chemistry*, 2nd ed. VCH, Weinheim, 1985.

The Haber-Bosch process step-by-step

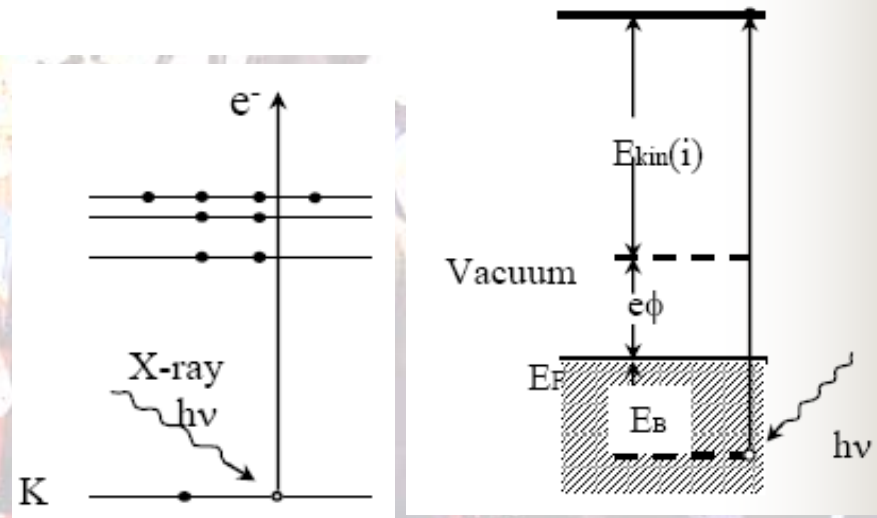
Straightforward to establish the **reaction mechanism**



The state NH_2 could not be quantified by spectroscopic methods, but instead by **co-adsorbing NH_3 and D_2**

use UPS, XPS, SIMS, HREELS

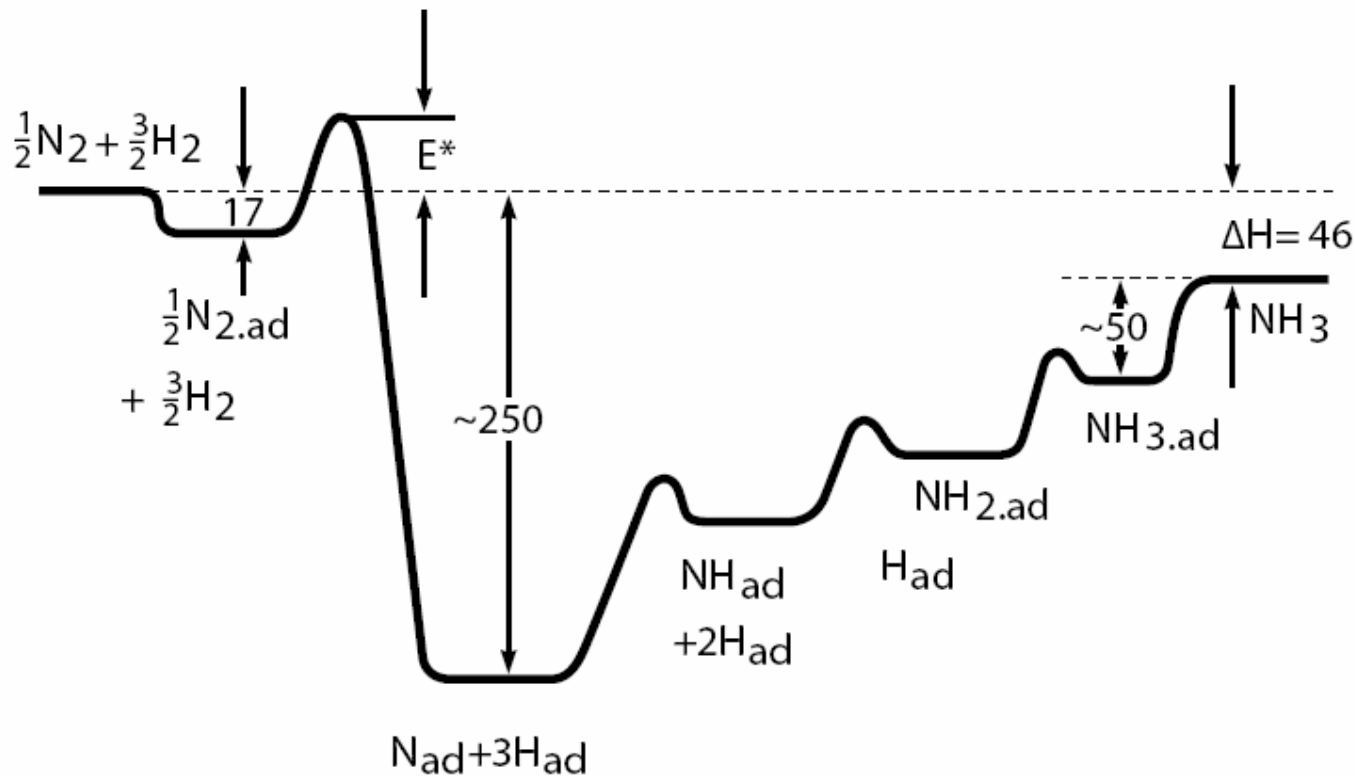
In the “**backward**” direction, which is favored at **low pressures**



G. Ertl and J. Küppers, *Low Energy Electrons and Surface Chemistry*, 2nd ed. VCH, Weinheim, 1985.

The Haber-Bosch process step-by-step

Straightforward to establish the **reaction mechanism**



Ertl's investigations of the reactions in the Haber-Bosch process serve as a model of **how sophisticated experimental methods** can be used to study a phenomenon of utmost practical relevance.

(Adapted from Ertl 1983)

Interview of the Nobel Laureate in Chemistry 2007

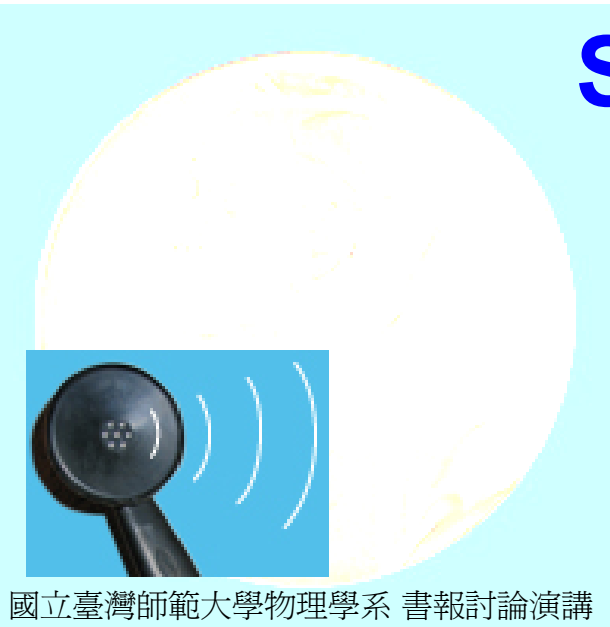
Patient!

But what's the **most important lesson** they (> hundred students) should learn from you, do you think?

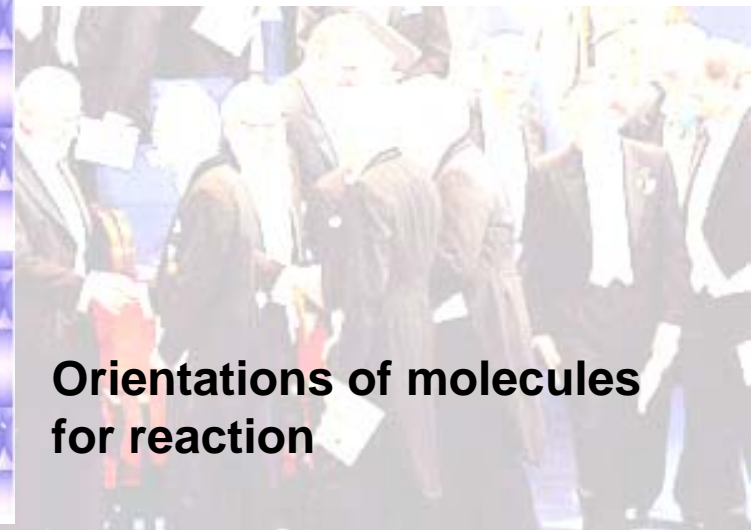
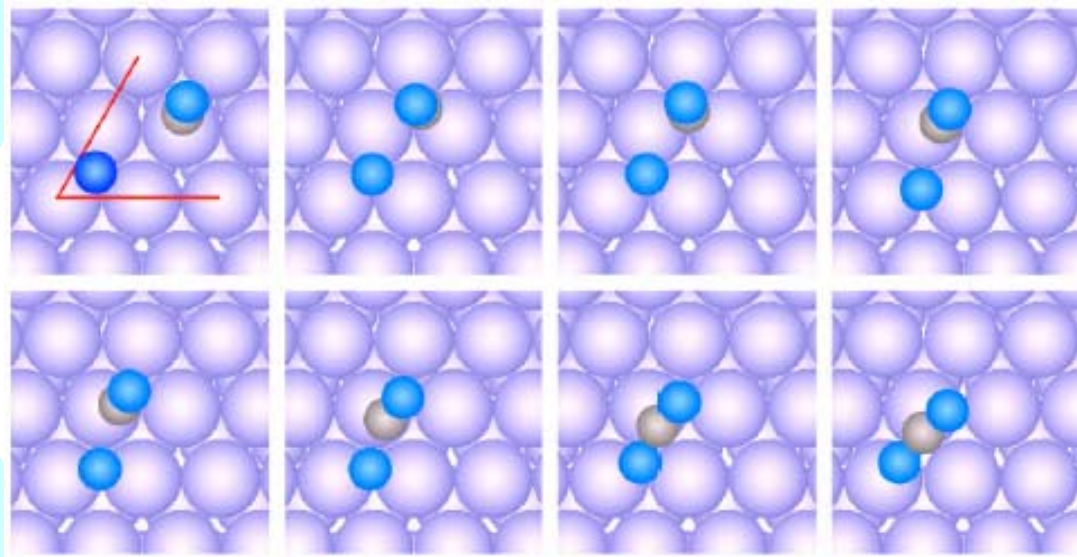
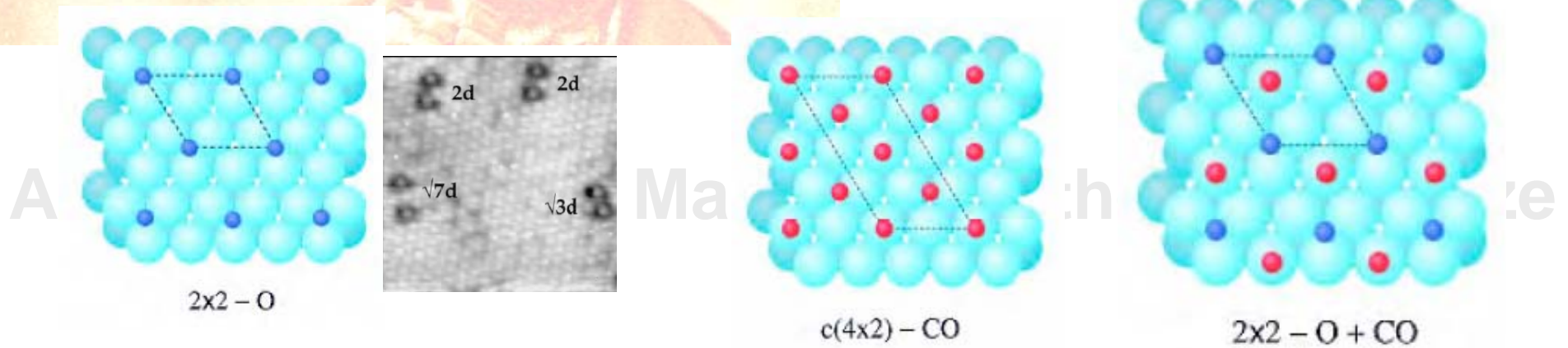
"And you must be **patient**. You *must* be **patient**.
That's very important."

Slow but accurate!

For **surface scientist**,
- also for all the researchers!

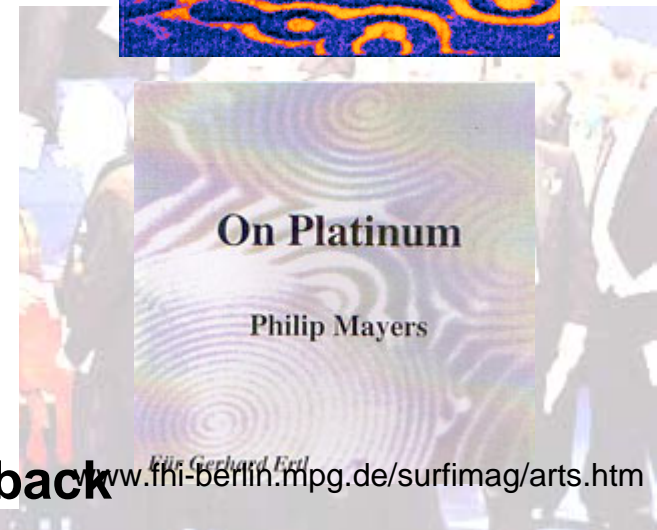
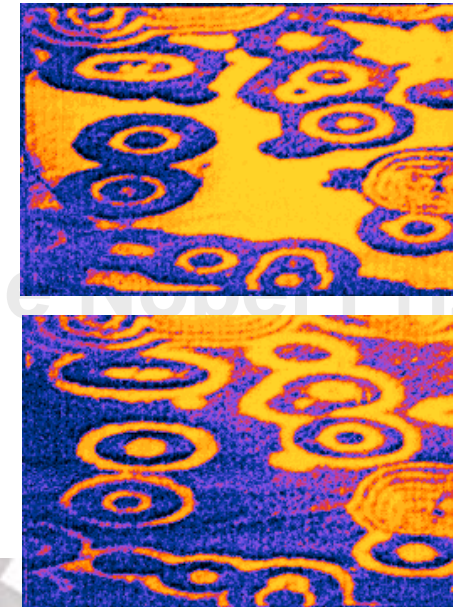
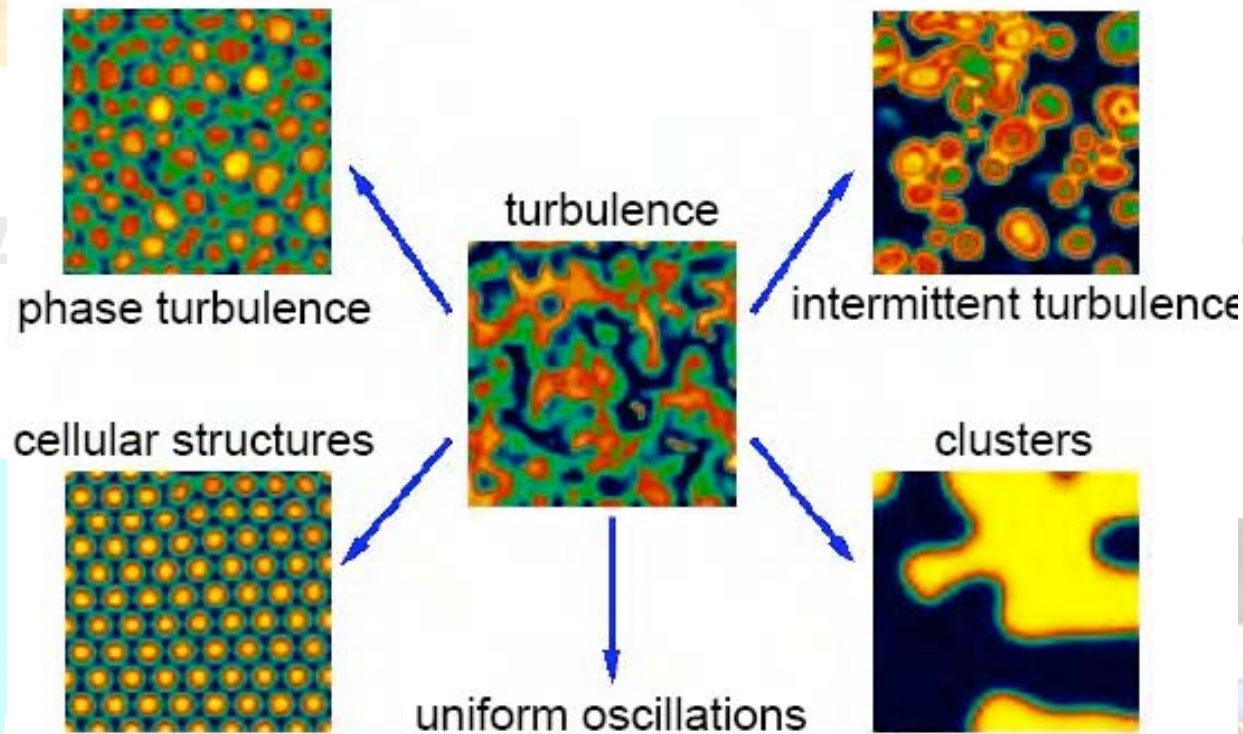


Heterocatalytic Reactions



Orientations of molecules for reaction

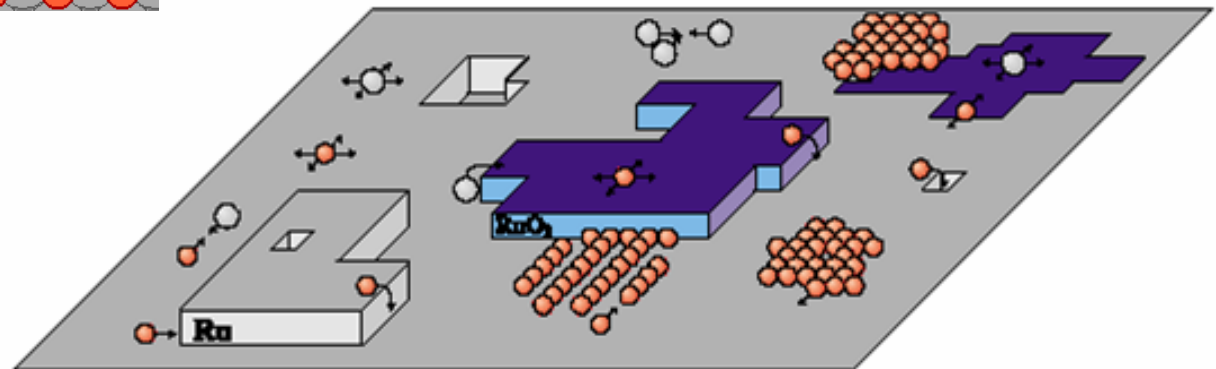
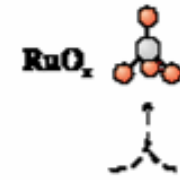
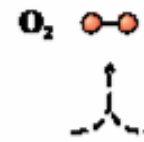
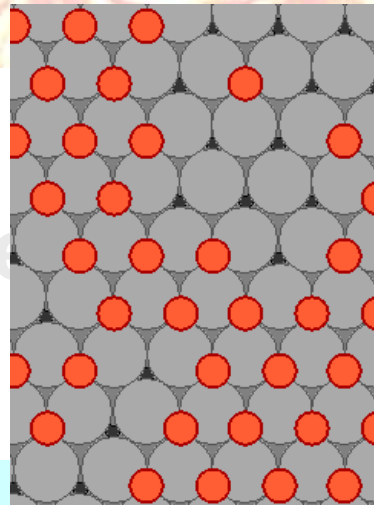
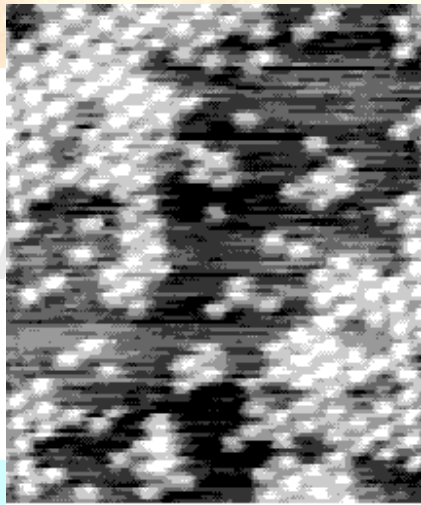
Pattern Formation



CO oxidation on Pt(110) with delayed global feedback

Atomic-Scale Imaging of Surface Processes

0.13 ML O/Ru(0001)



Concluding remarks

His methodology **sets a standard** for how chemical processes on surfaces can be studied and elucidated.

Alfred Nobel - The Man Behind the Nobel Prize

(1) Always use the **method best suited to solve the problem at hand**.

(2) never satisfied with an isolated interesting observation. Instead the studies are **brought to their logical conclusions**.

(3) Through his **accurate studies**, he has provided a firm basis for our thinking about molecular processes at surfaces.



Alfred Nobel - The Man Behind the Nobel Prize

