

Innovation in scientific research

Suggestions for discovery

- Problem choice: Think big
 - Routine problems are often as hard as big ones.

Suggestions for discovery

- Problem choice: Think big
 - Routine problems are often as hard as big ones.
- Technology drives science
- Dare to explore uncharted areas

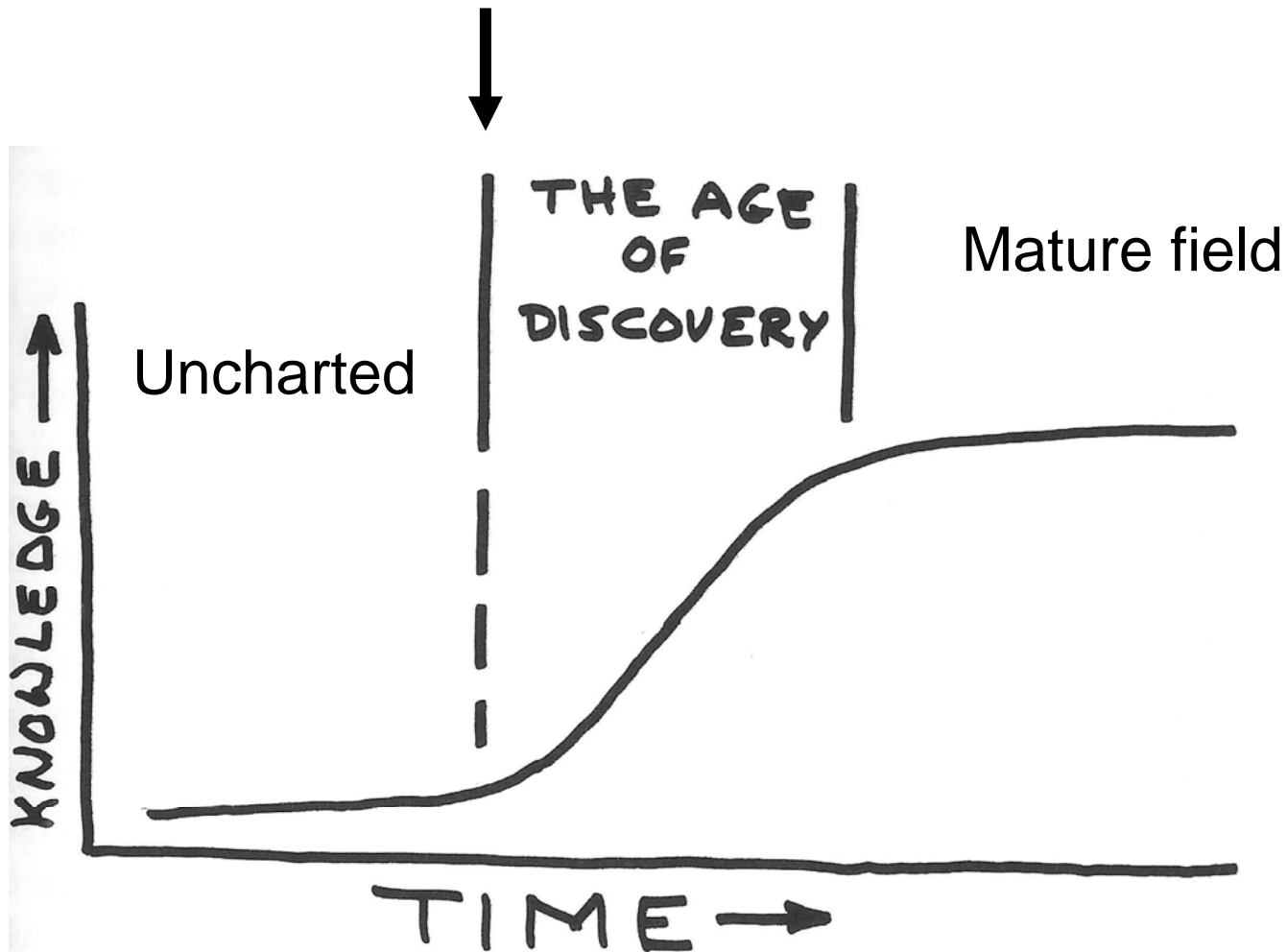
Suggestions for discovery

- Problem choice: Think big
 - Routine problems are often as hard as big ones.
- Dare to explore uncharted areas
- Be ready to change fields

Suggestions for discovery

- Problem choice: Think big
 - Routine problems are often as hard as big ones.
- Dare to explore uncharted areas
- Keep pushing into new areas
- Don't ignore things that seem off-track
- Crazy theories are either crazy or hugely important
- Work hard

The time of opportunity

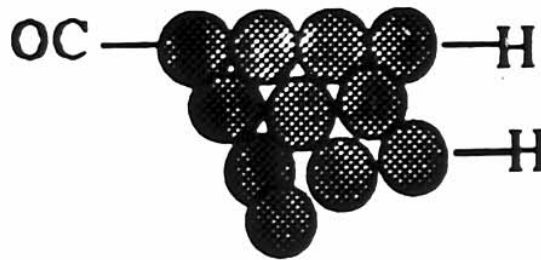




Rick Smalley in his lab at Rice circa 1978

Clusters

- A new approach to Surface Chemistry



- The development of bulk states

Molecules



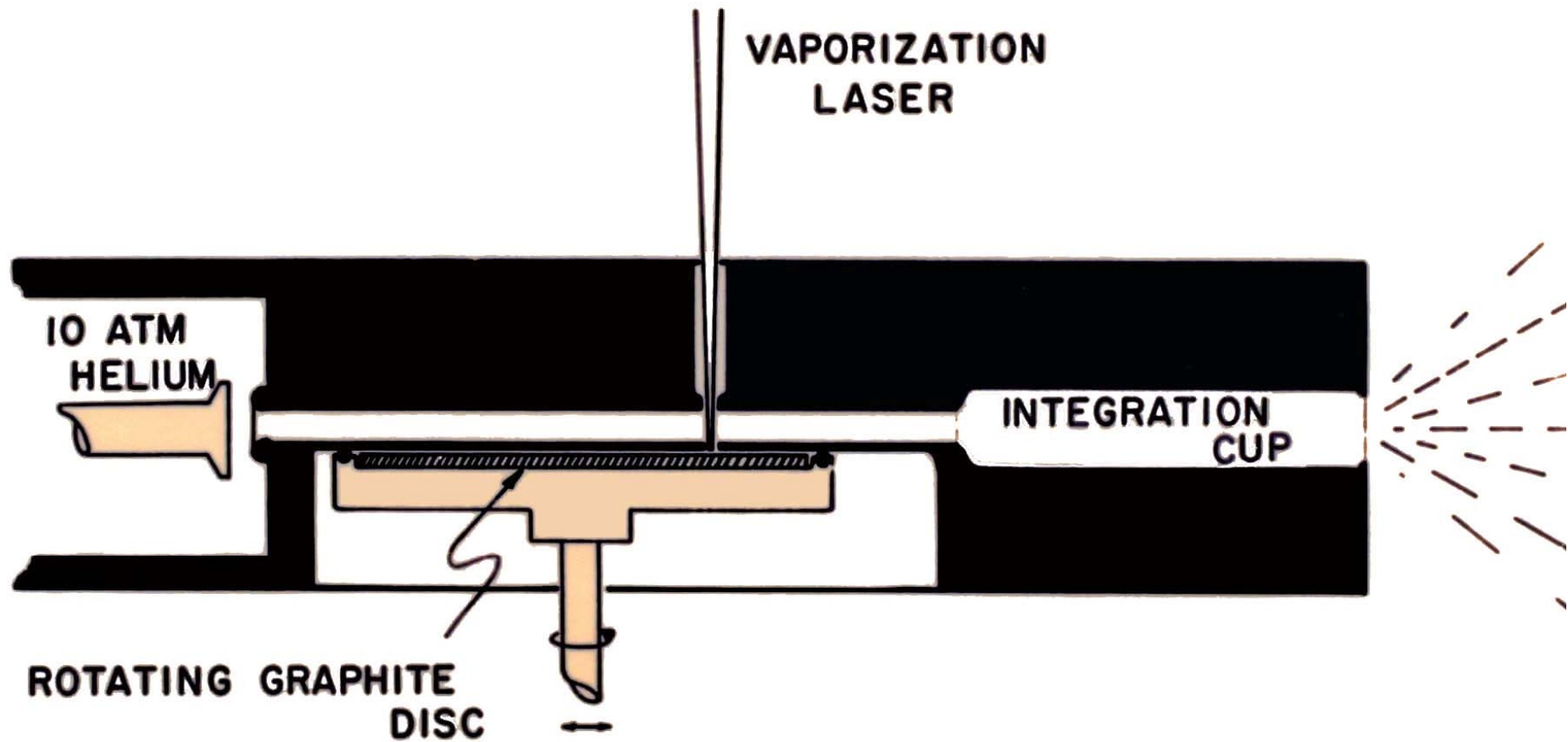
Clusters



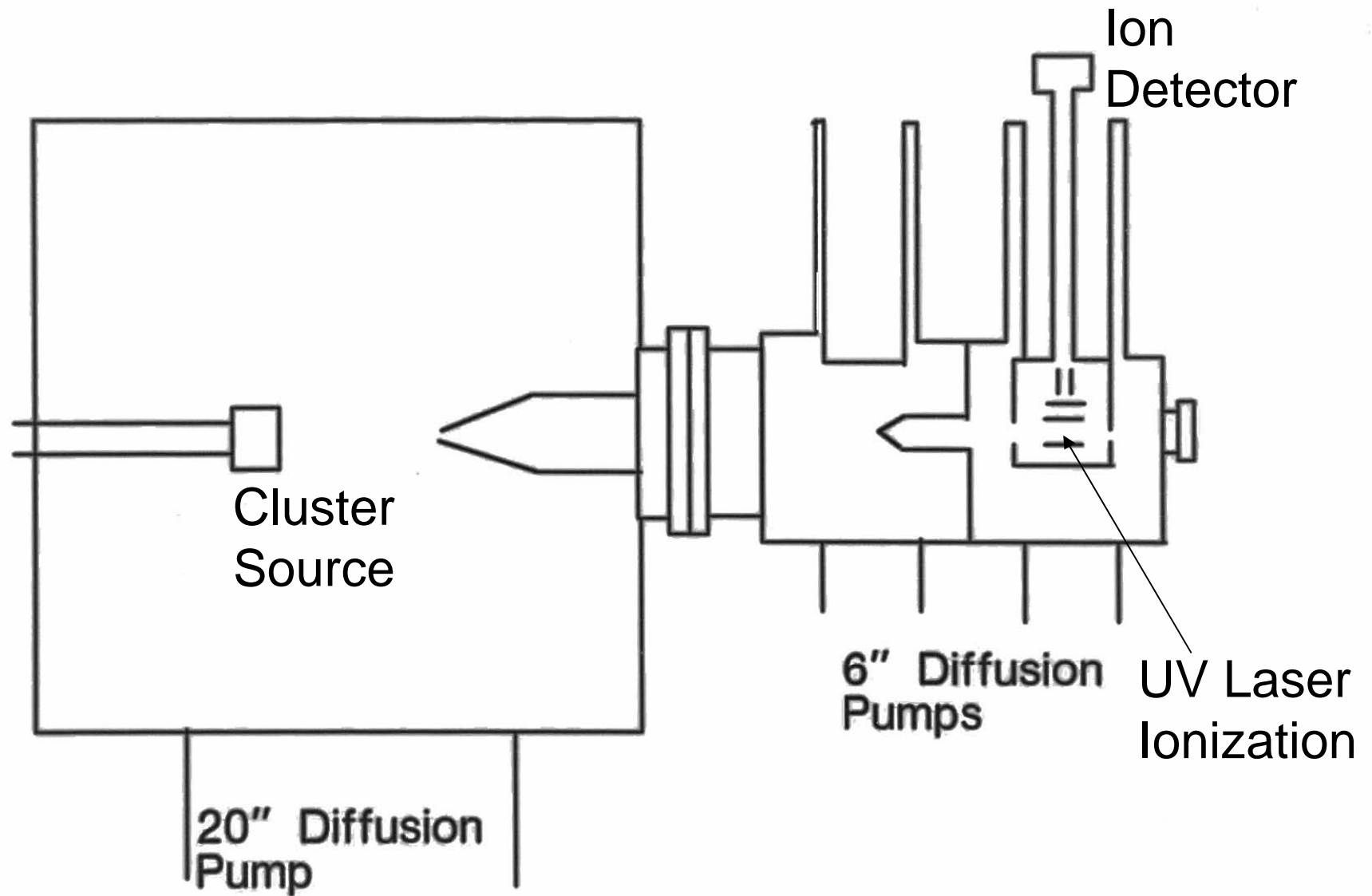
Bulk



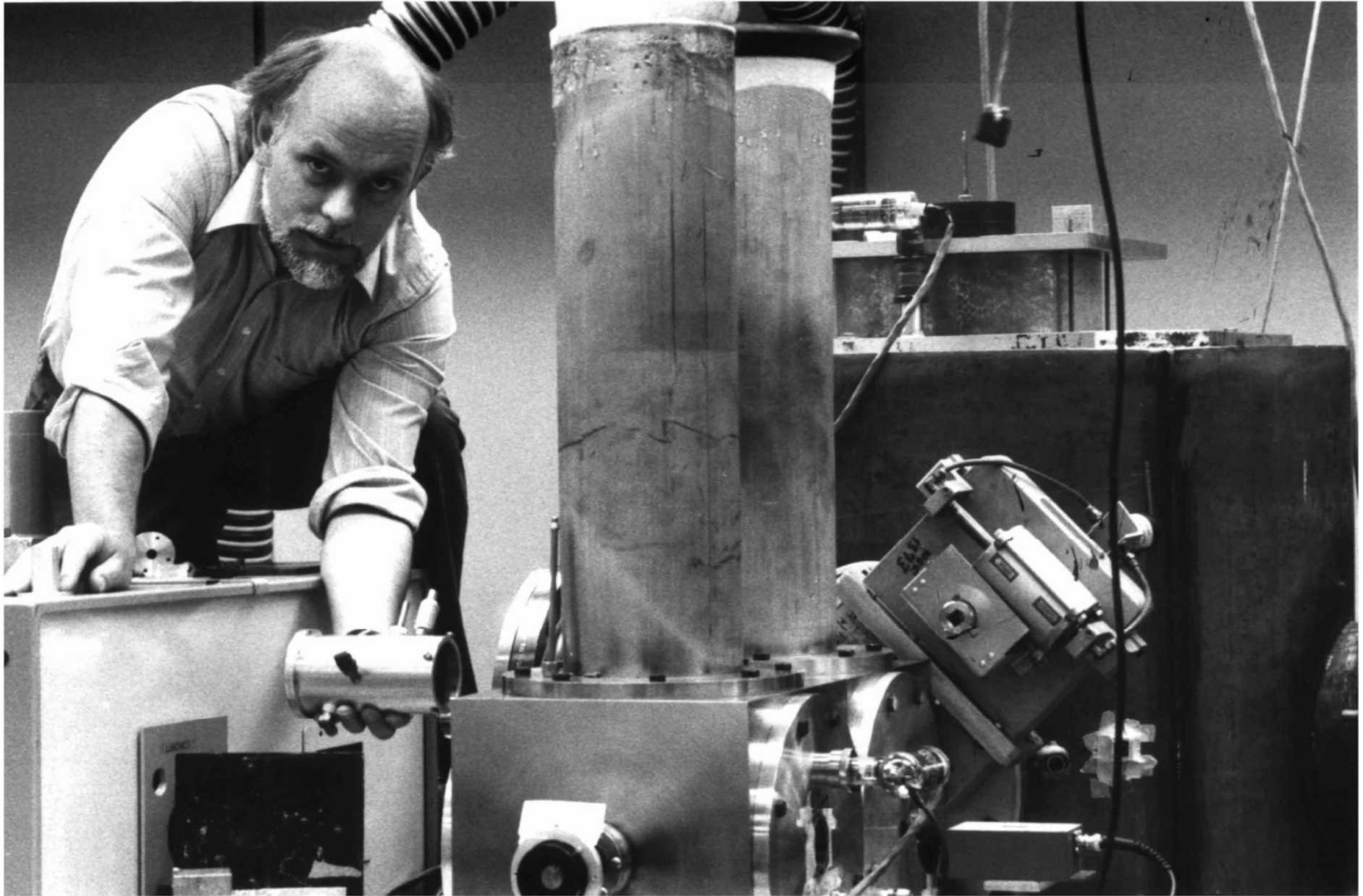
Cluster beam source



AP2: Cluster beam TOF mass spectrometer



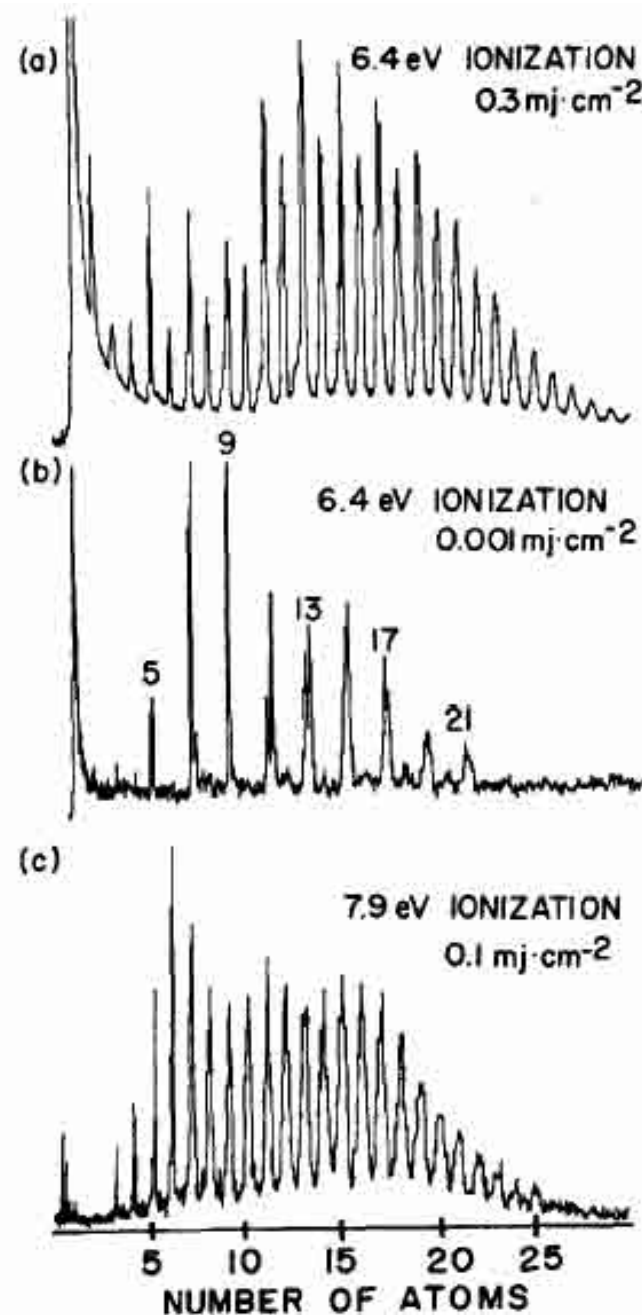
Rick atop Ap2



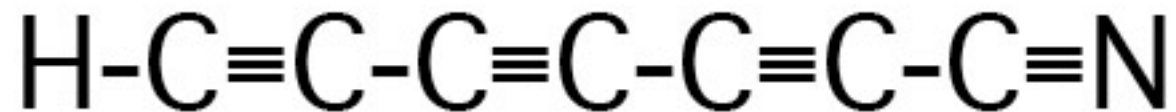
GaAs Cluster Ionization

Magic numbers in
GaAs cluster
ionization potentials

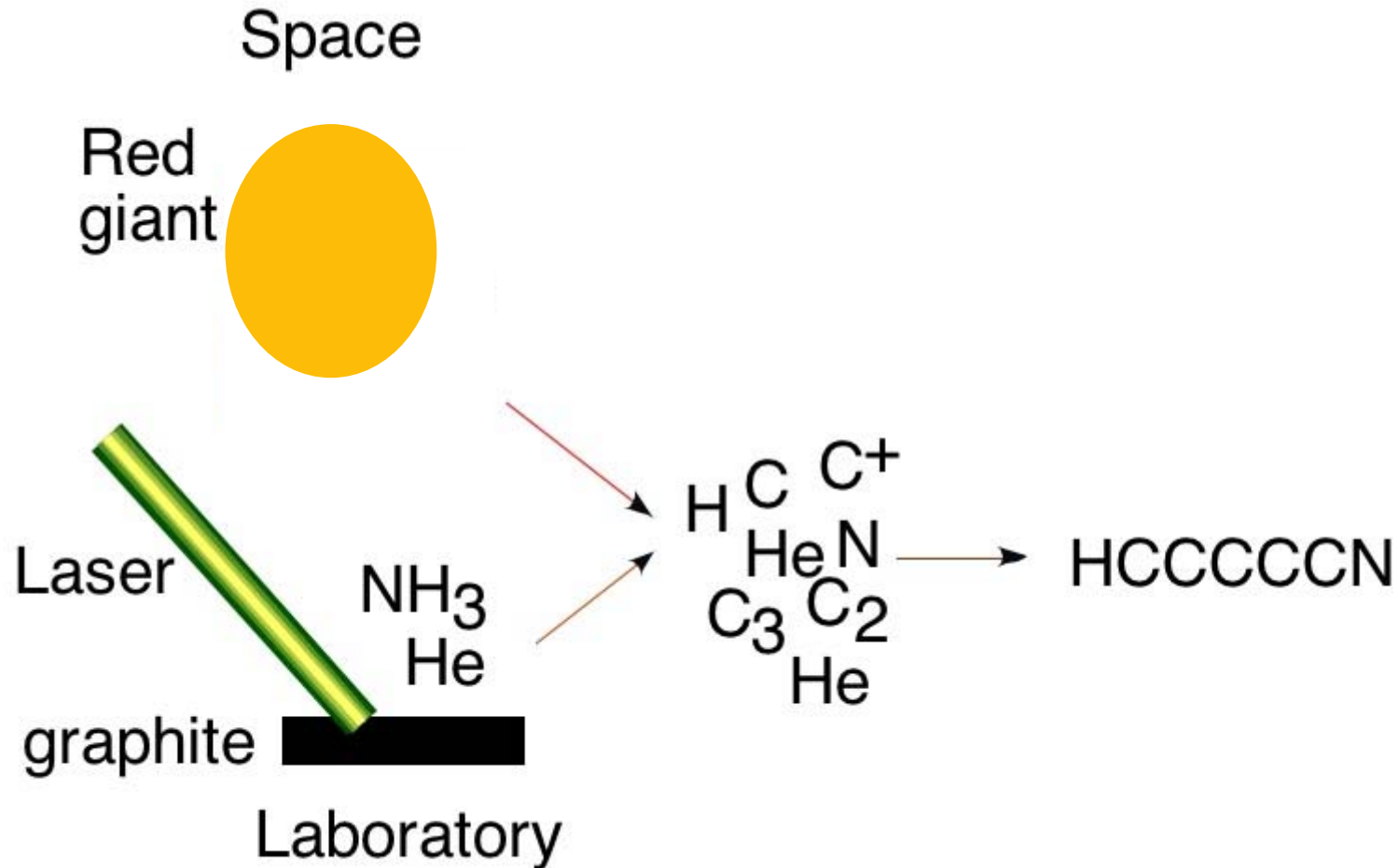
O'Brien, S. C.; Liu, Y.;
Zhang, Q.; Heath, J. R.;
Tittel, F. K.; Curl, R. F.;
Smalley, R. E. *J. Chem.
Phys.* 1986, **84**, 4074.



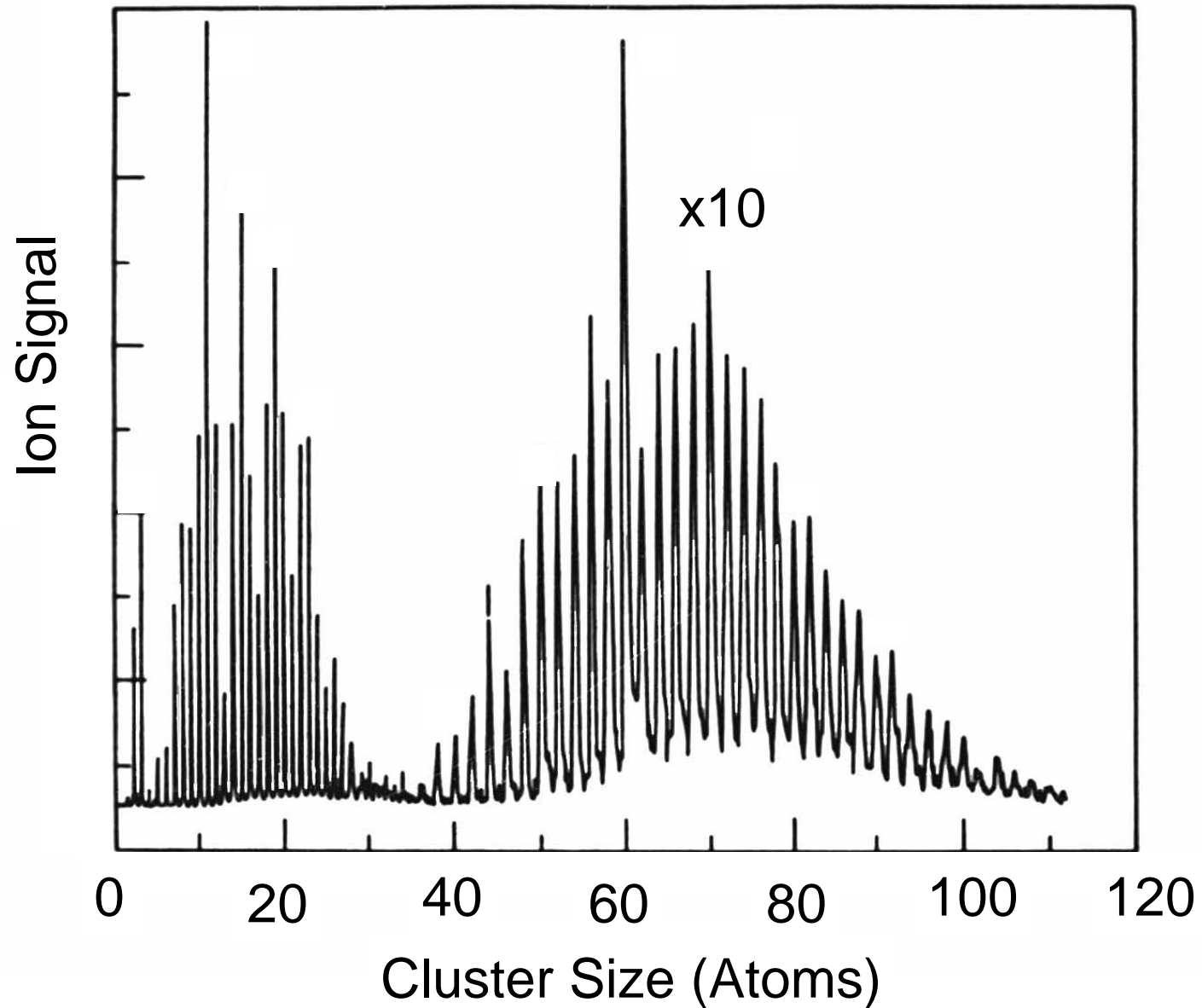
Carbon Chain Molecules Found in Interstellar Clouds

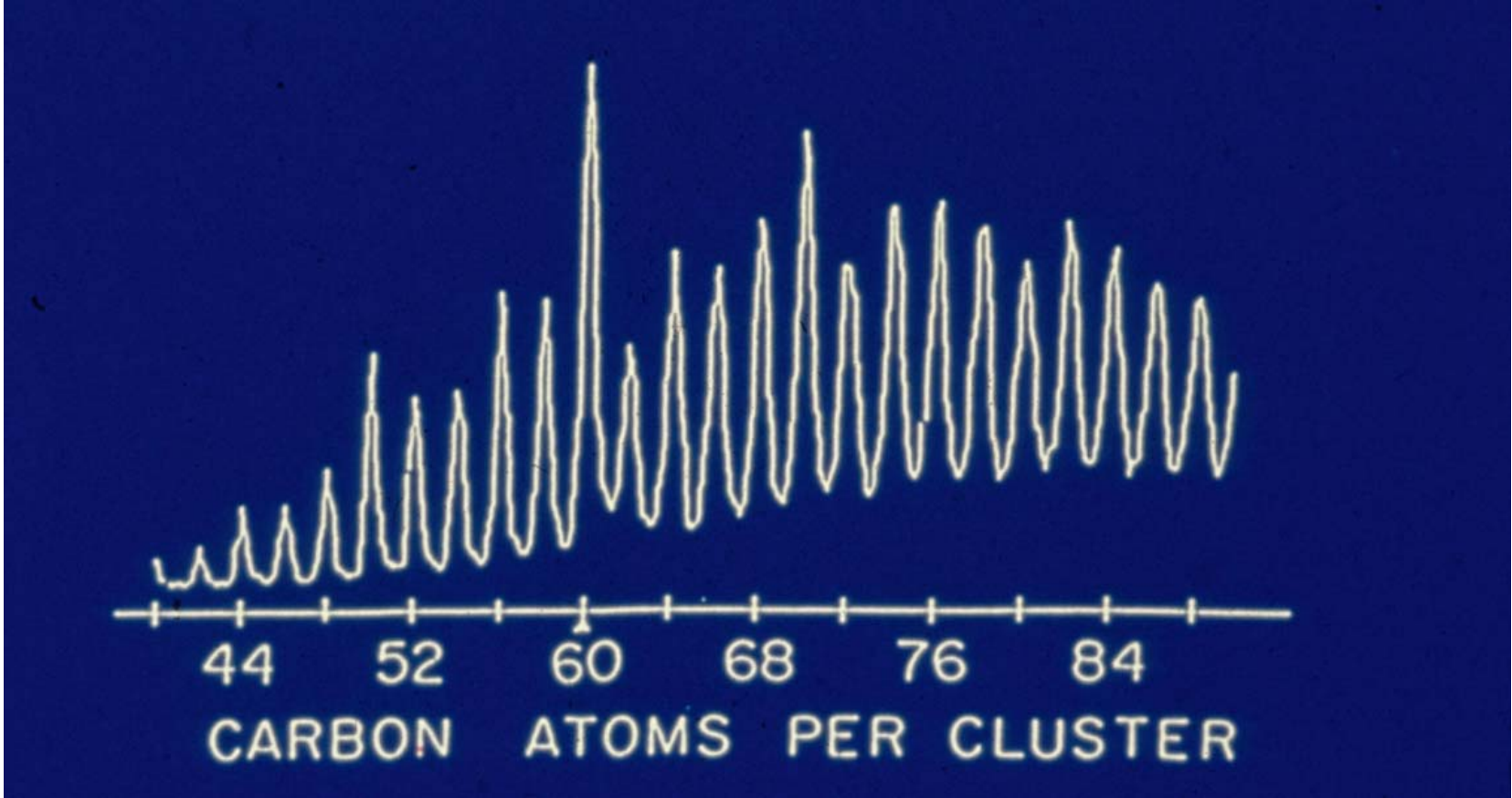


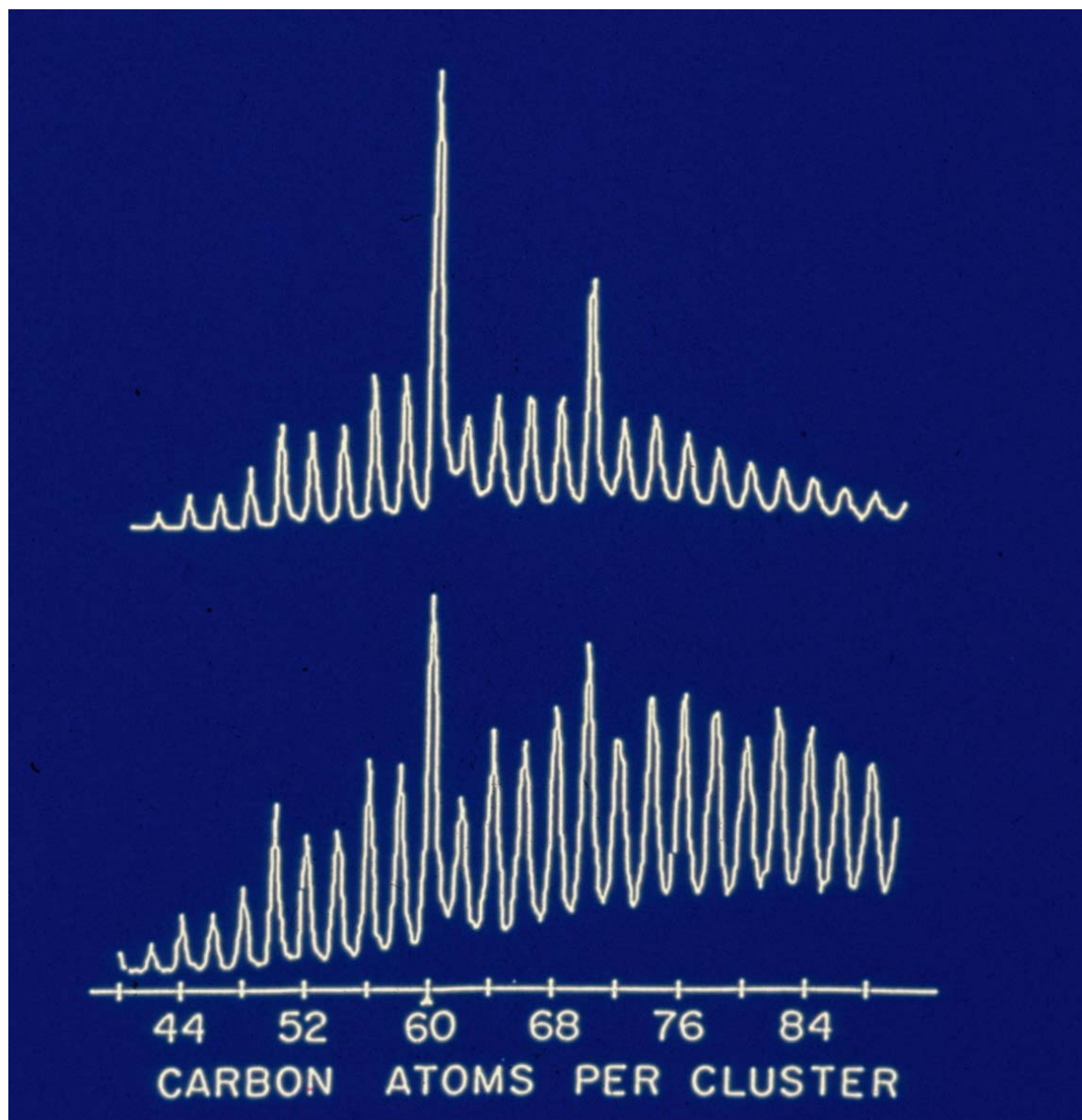
Emulating the Stars in the Lab

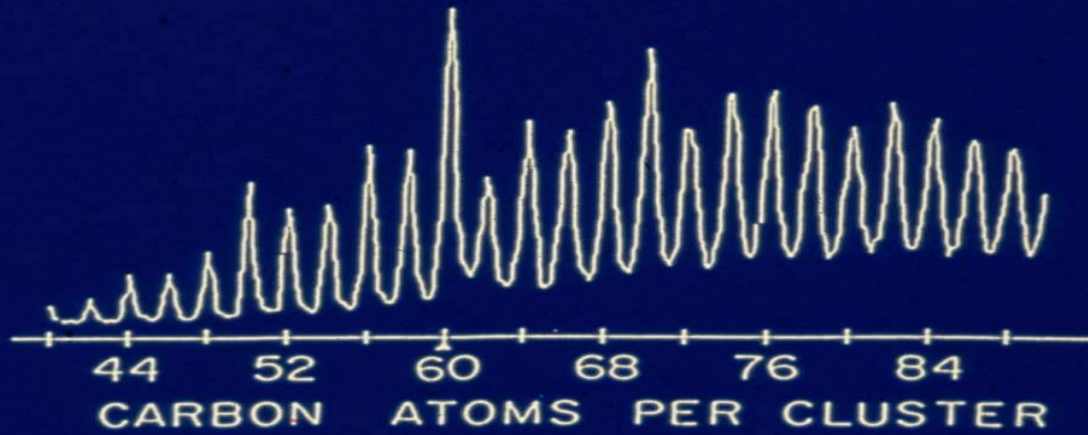
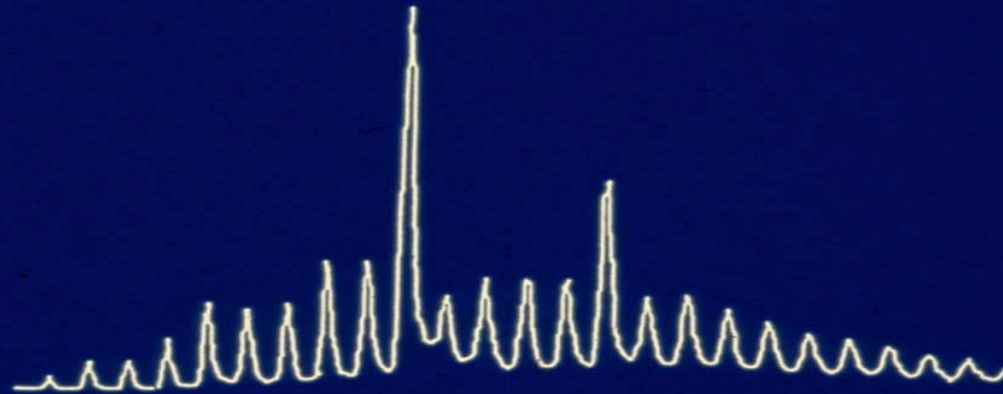
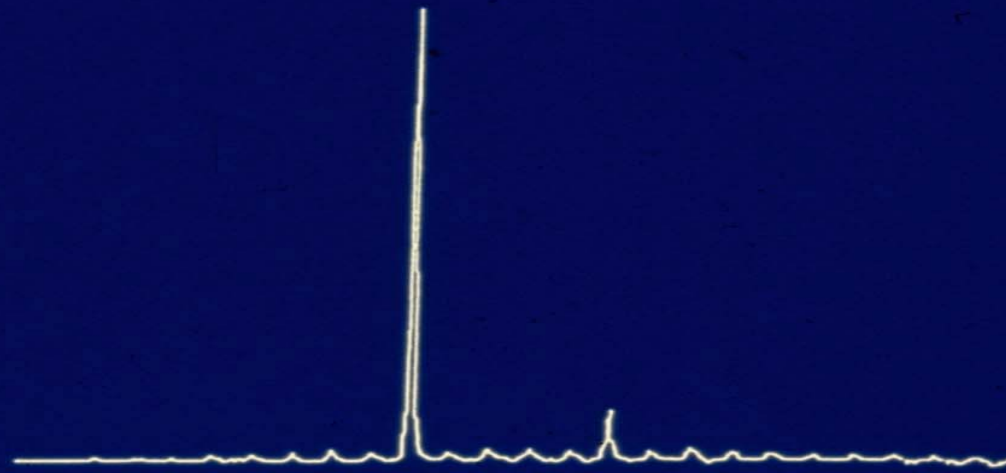


Rohlfing, Cox, and Kaldor, Supersonic Carbon Cluster Beams

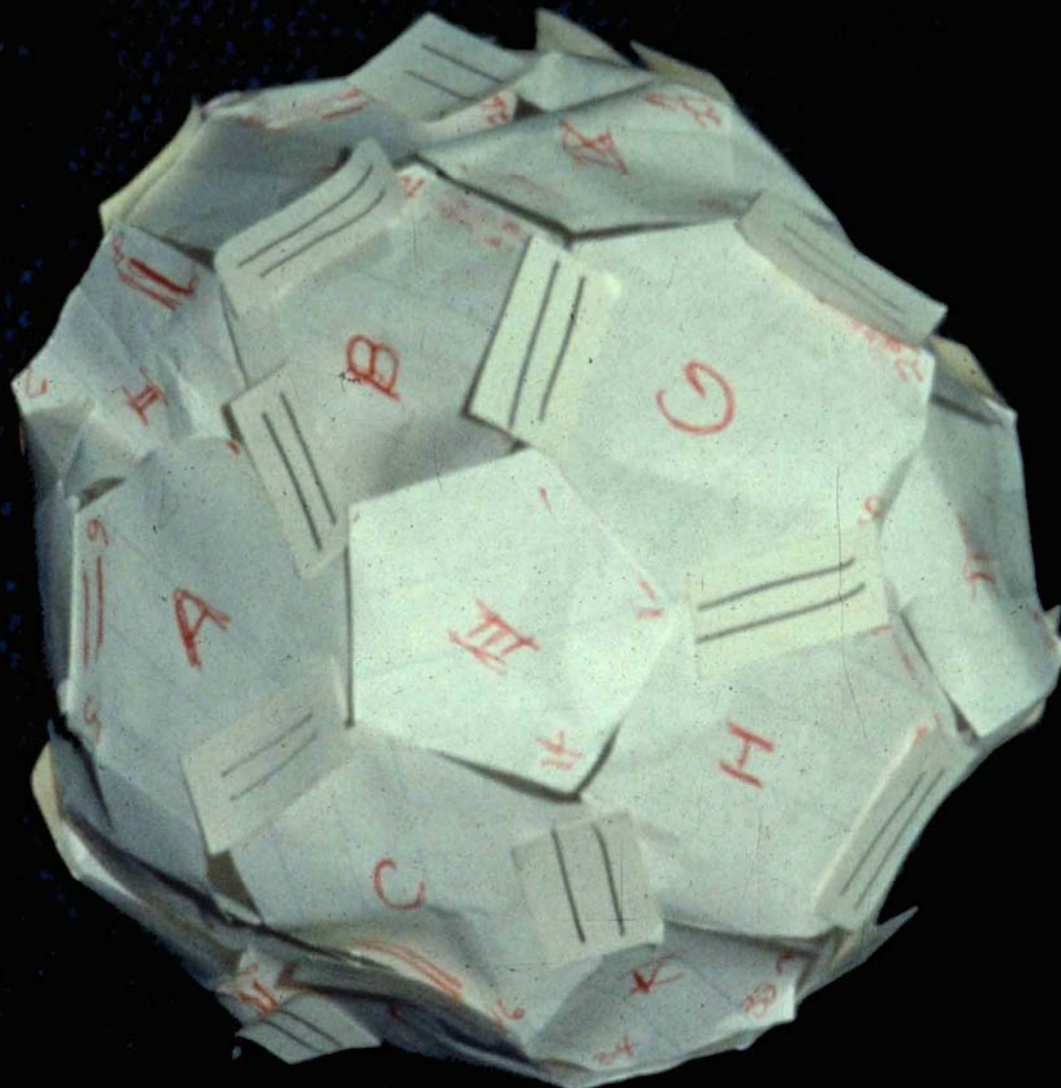








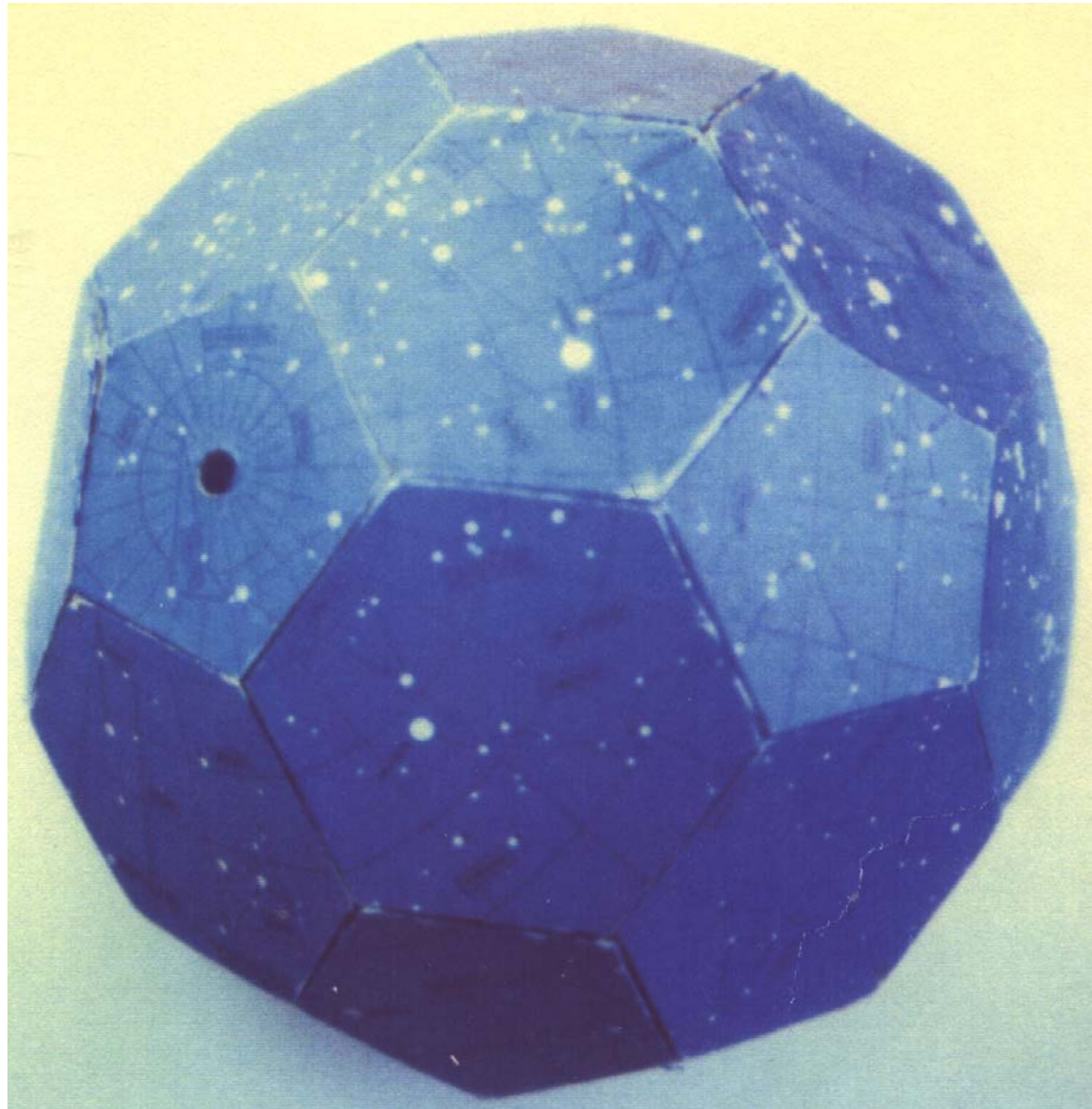
Smalley's C_{60} Paper Model



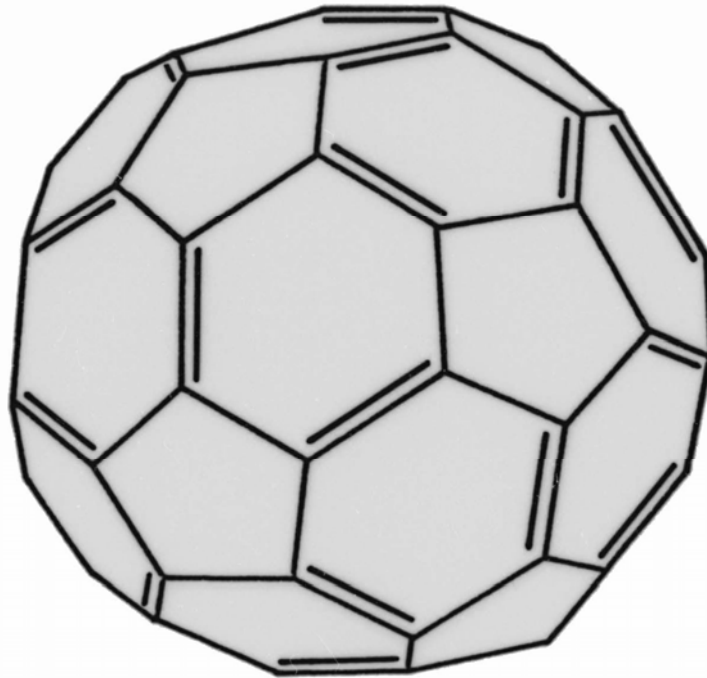
Kroto's

Stardome

Map of the sky
on a truncated
icosahedron
consisting of
pentagons as
well as
hexagons

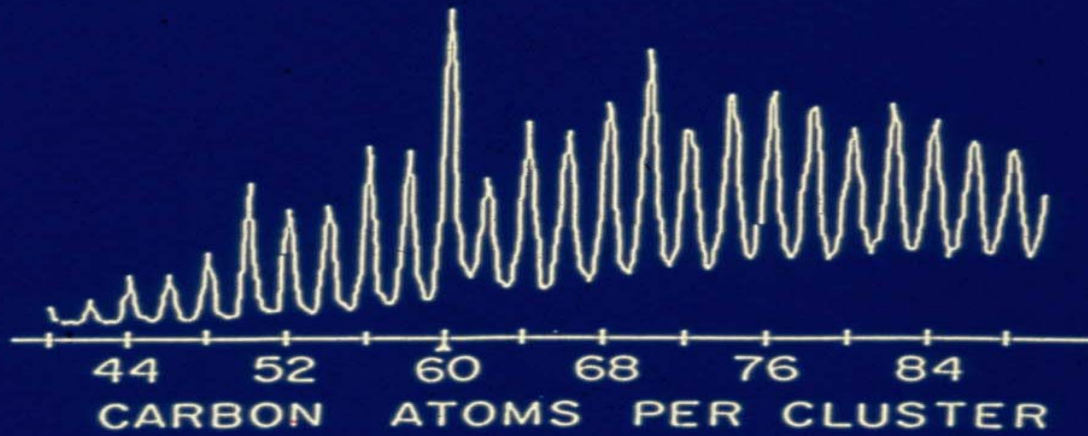
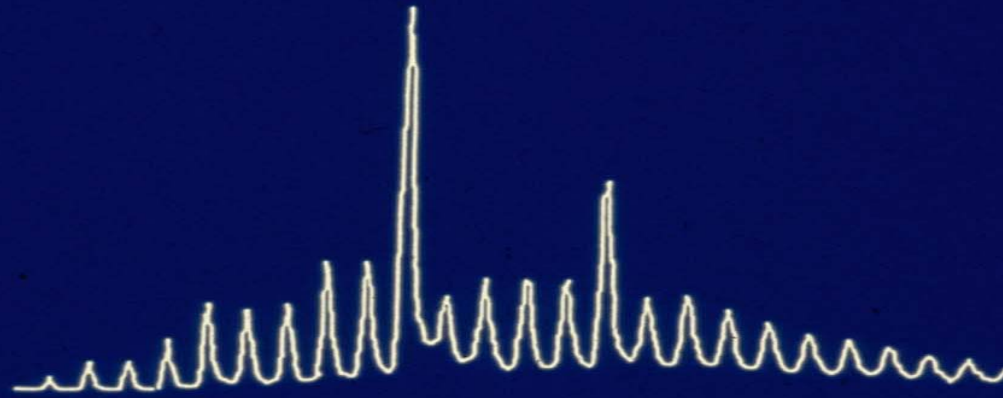
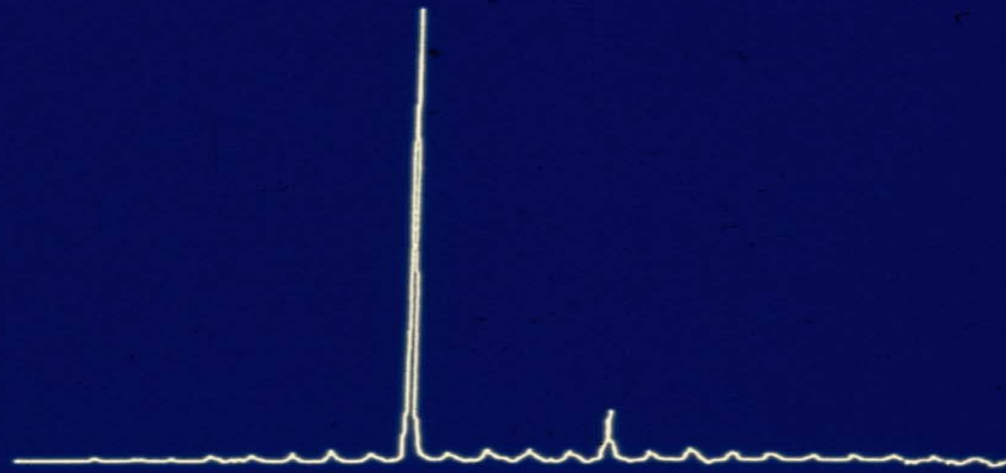


Buckminsterfullerene

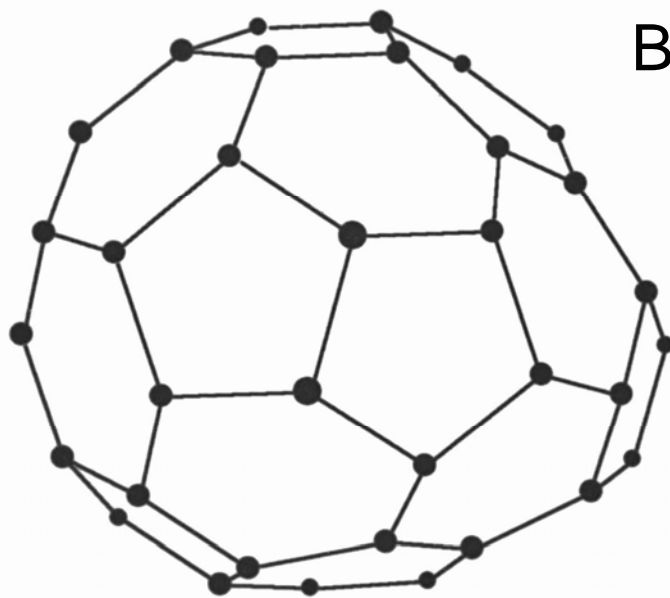


C_{60}

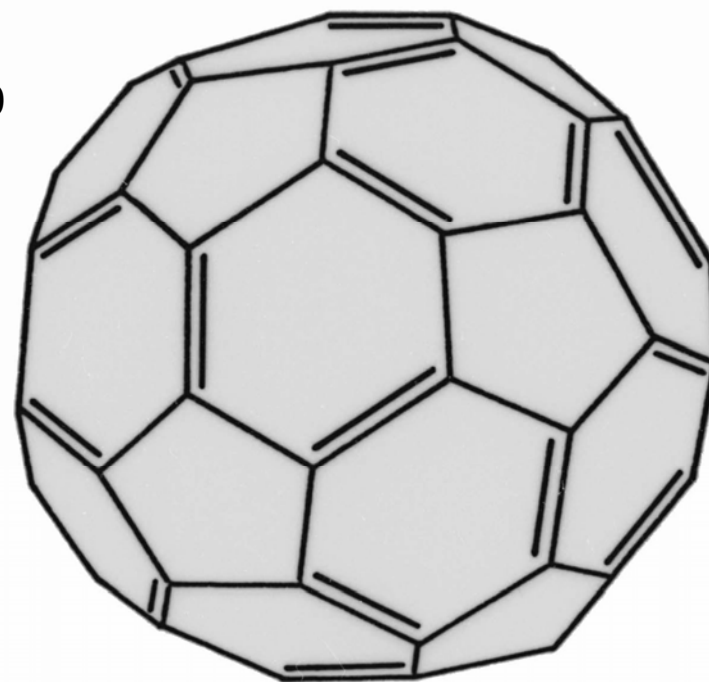




Adjacent Pentagon Fullerenes



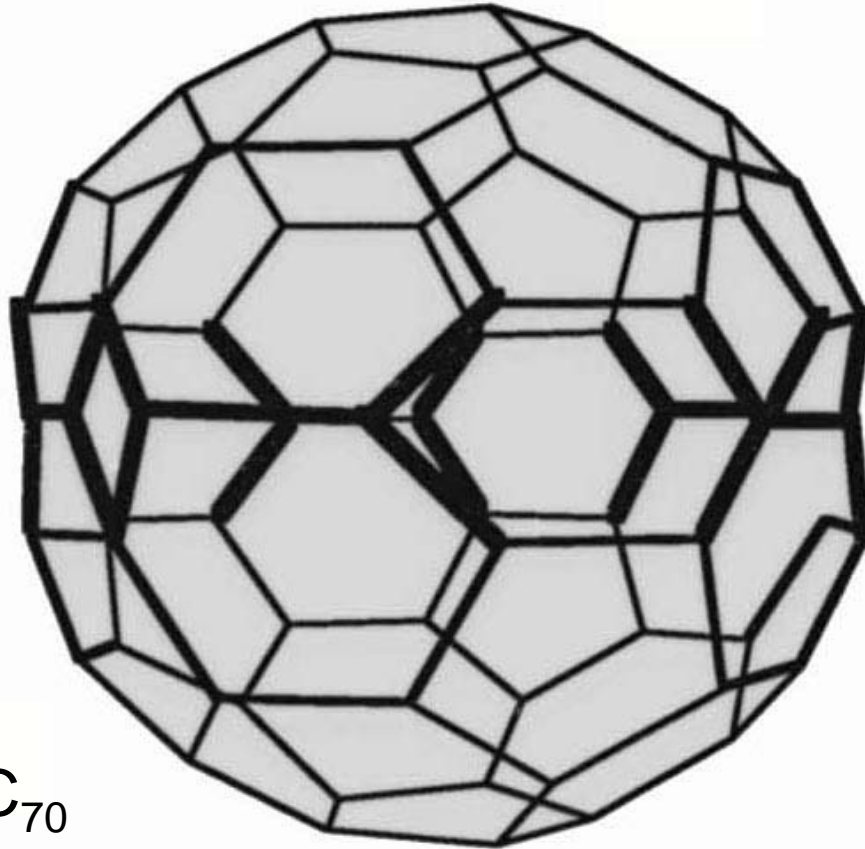
Both C₆₀



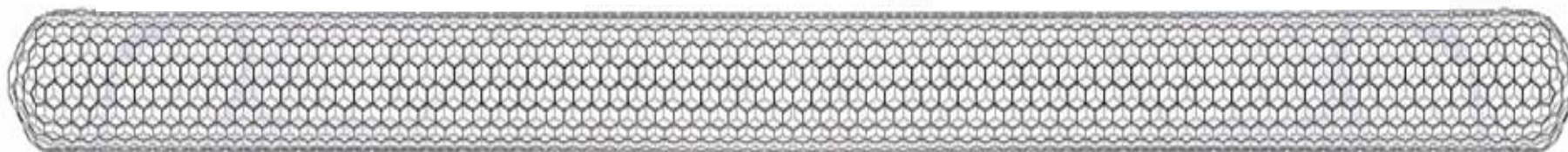
One of 1812 fullerene isomers
with 60 carbon atoms

Buckminsterfullerene

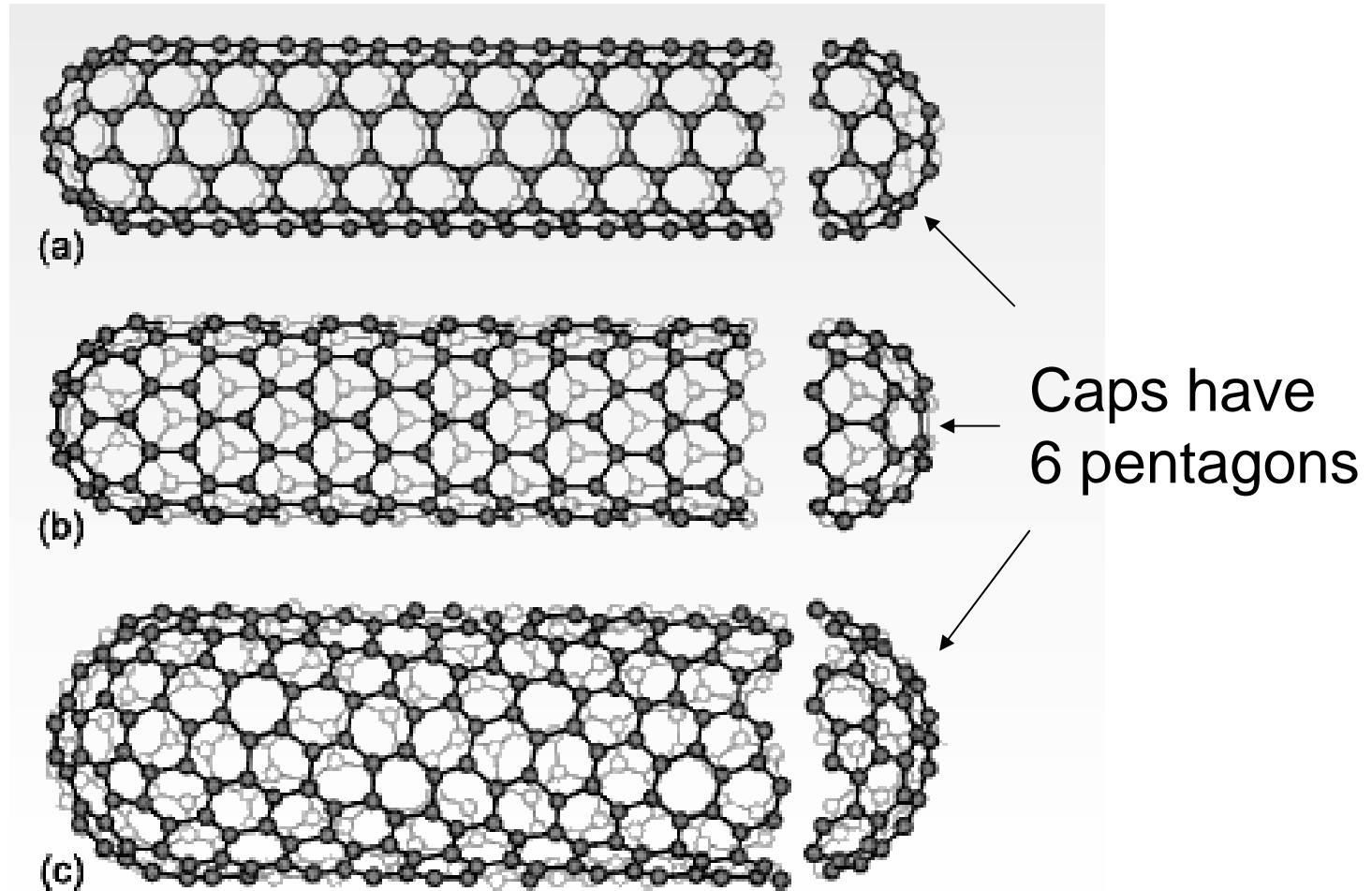
After bucky C_{60} , this C_{70} structure is the first without adjacent pentagons



Long fullerene

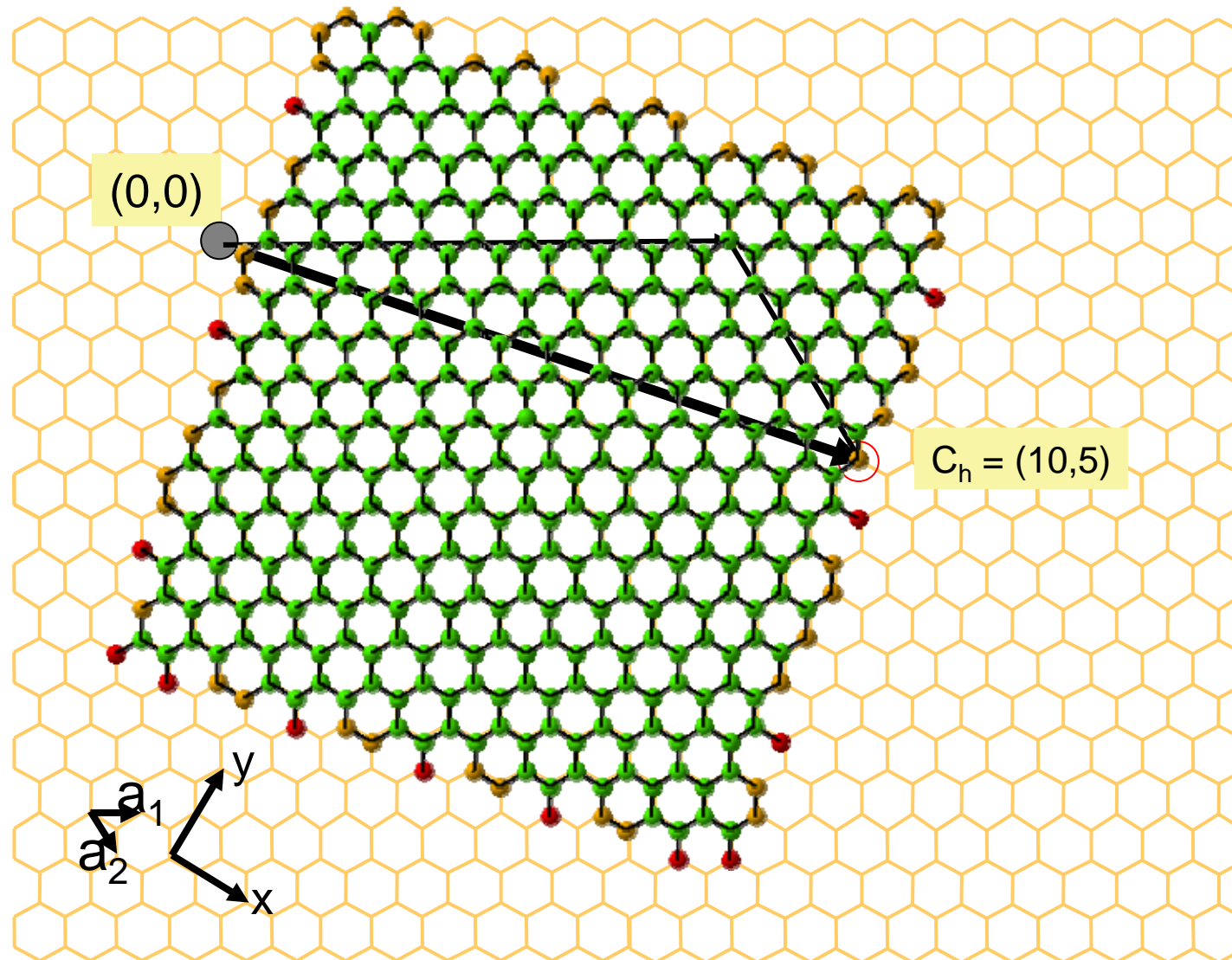


Kinds of Nanotubes

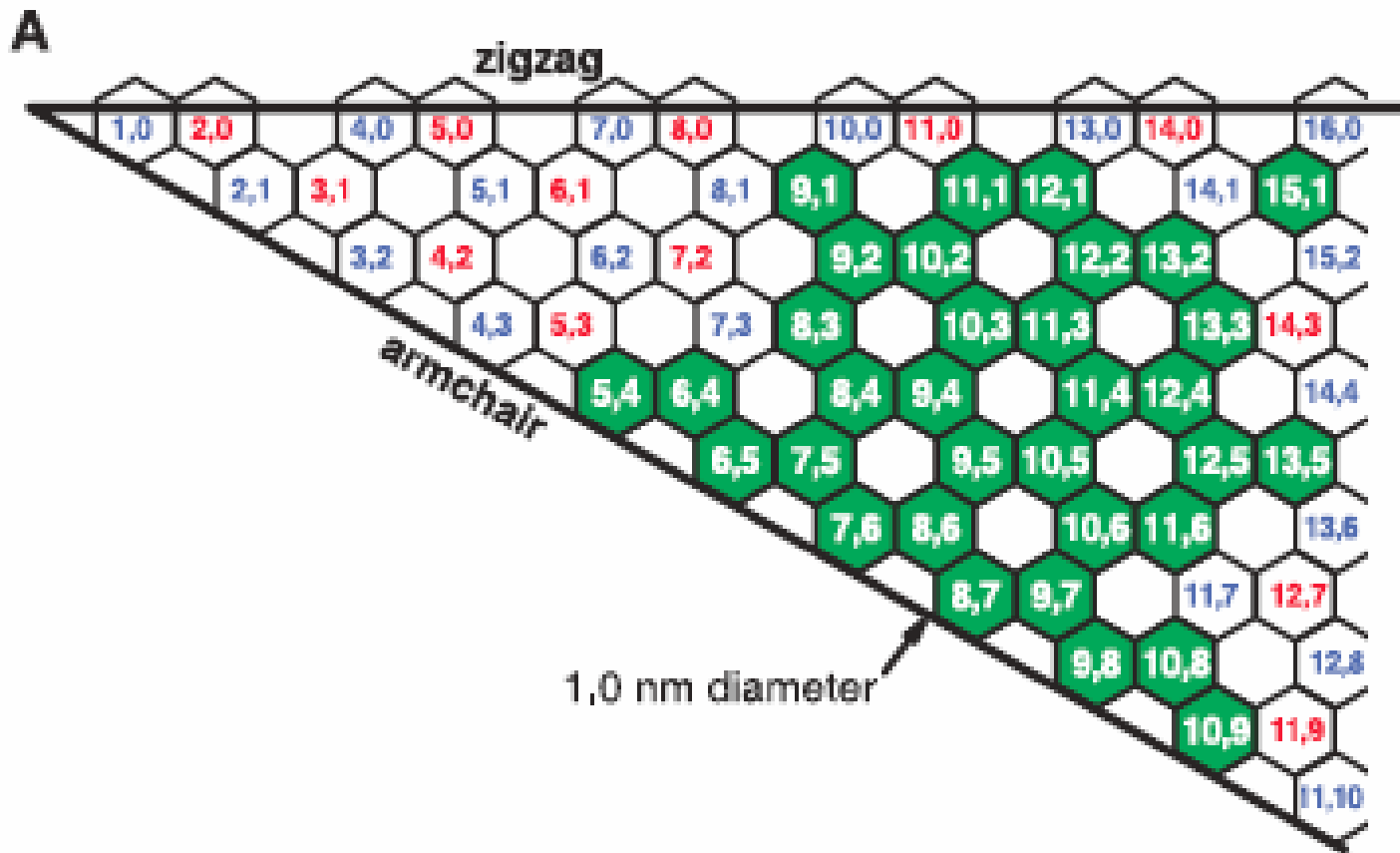


Nanotubes (a) armchair (b) zig zag (c) chiral

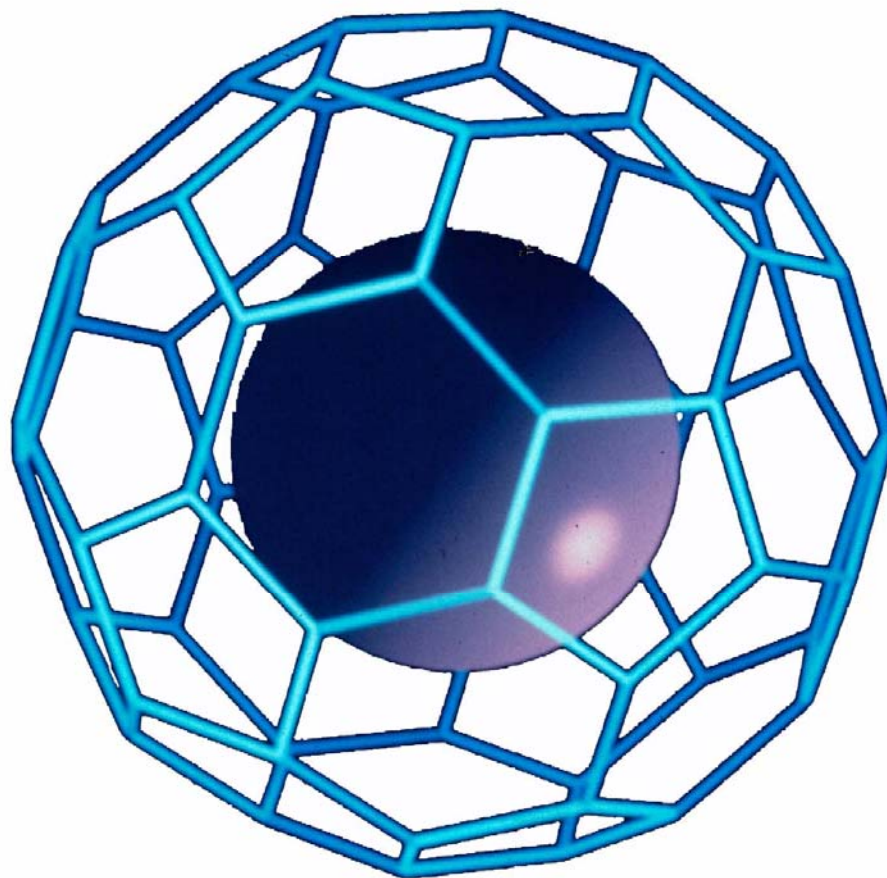
Structure of a (10,5) SWNT



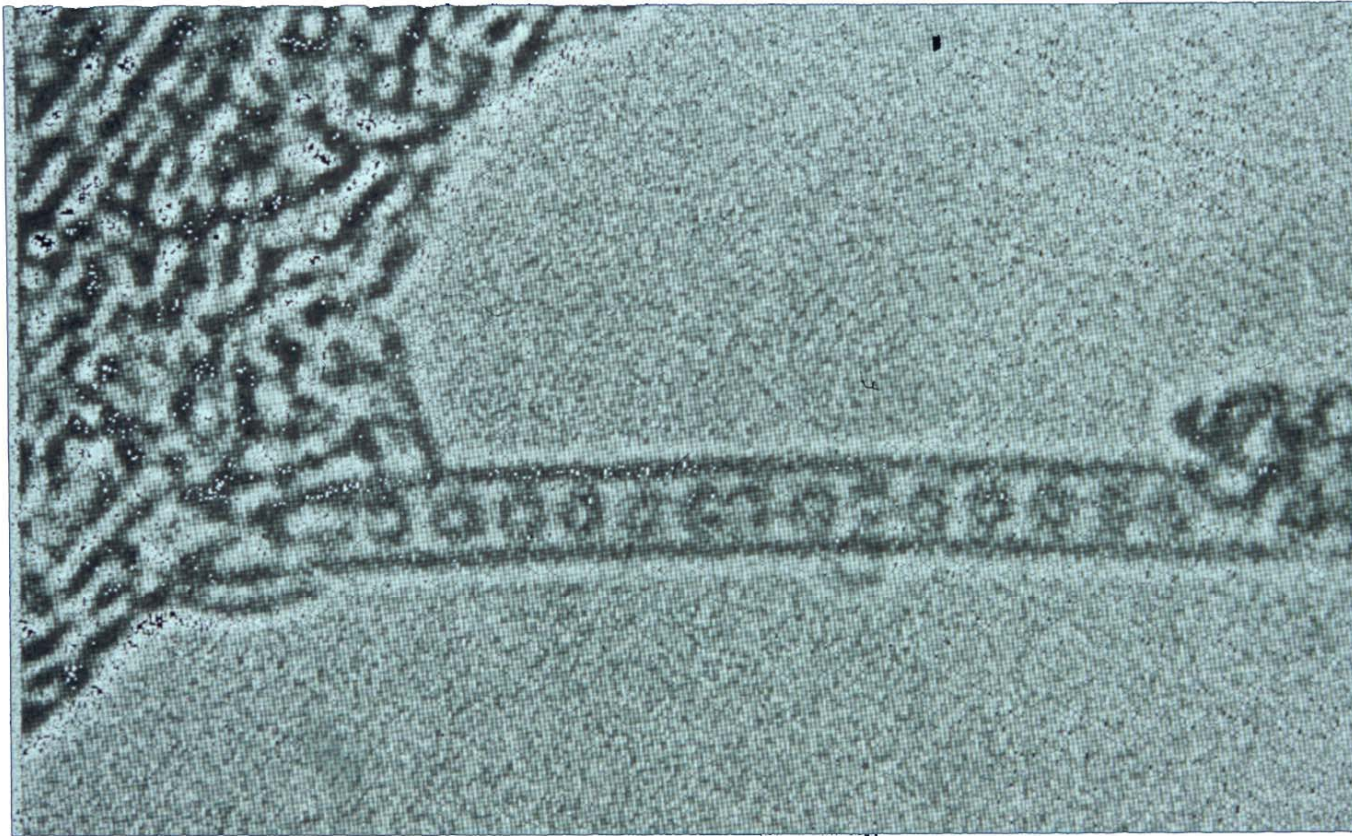
Nanotubes found



Endohedral Structures

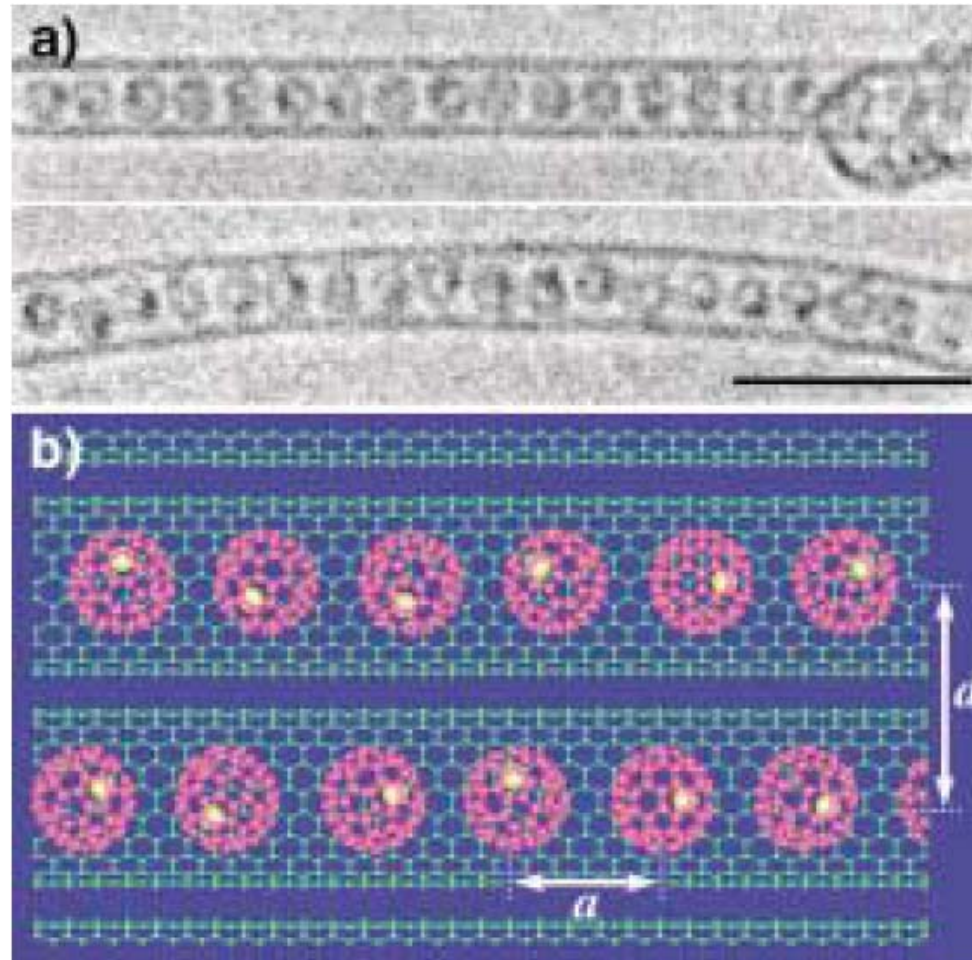


Peapod Structure: Bucky in SWNT



D. E. Luzzi, M. Monthieux, B. W. Smith

Peapods of Gd@C₈₂



Hirahara *et al.*

Commercial Applications of Fullerenes and SWNTs

At present **1** (serious)



Contains carbon nanotubes

Potentially **Many**



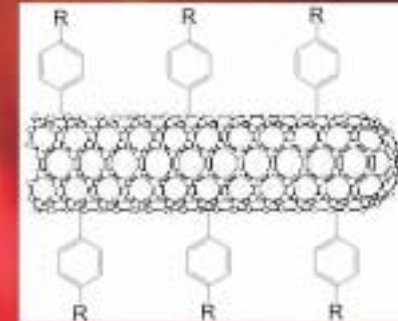
Contains C₆₀

Potential Applications

- Nanotubes
 - **Composites**
 - H₂ storage
 - Batteries
 - **Fibers**
 - Flat panel displays
 - Vacuum electronics
 - Pharmaceuticals
 - **Spacecraft CO₂ scrubbers**
 - Sensors
 - Super capacitors
 - Solar cells
- Fullerenes
 - **e⁻ resists**
 - Pharmaceuticals
 - Solar Cells
 - Light harvesting
 - **Composites**
 - Batteries
 - Proton permeable membranes

THE NEXT, BIGGEST DEVELOPMENT IN ELASTOMERIC OILFIELD PRODUCTS

may be found at the center of this poster



O-ring testing results

Sample	Pressure (psi)	Extrusion Gap (in.)	Failure Temp. (°F)	Comments
Nano-Composites 1290	15K	0.017	350	Held pressure for one hour, no commercial material compares in performance
Std. HNBR1	15K	0.017	250	Unable to pressurize
Std. HNBR2	15K	0.017	250	Held for 15 sec.
Std. HNBR3	15K	0.011	250	Unable to pressurize
Std. HNBR4	15K	0.011	250	Held for 2 min
Std. HNBR3	15K	0.005	250	Held for 2 min 11 sec

Hydriil products have long been found at the leading edge of what works while Hydriil engineers have been developing what's next. That's why we have partnered with NanoComposites, Inc., with the goal of leveraging Rice University's patented technology for single-walled, carbon nanotubes into the next revolution in oil products. Imagine elastomer "software" as durable as the hardware. Imagine if packers and seals simply didn't care how much heat, sand or fluids they encountered. What if an old annular nano-engineered packing unit could outperform newbies? We're inventing this revolution now. What's the future for the O-ring shown above? Follow Hydriil for the answers as they become available.

R E F I N I N G R E L I A B I L I T Y™

