

# ROTATIONAL MOTION

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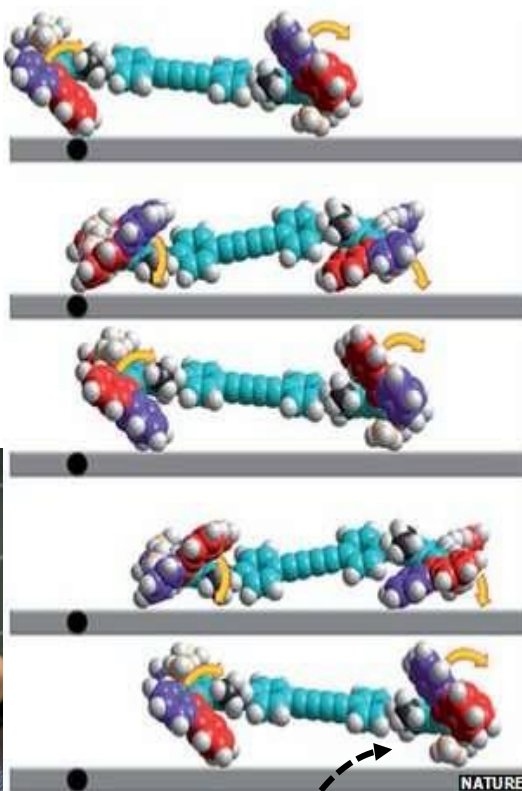
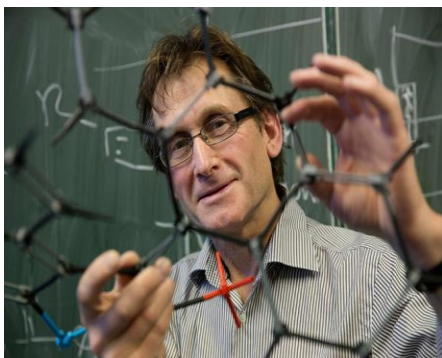
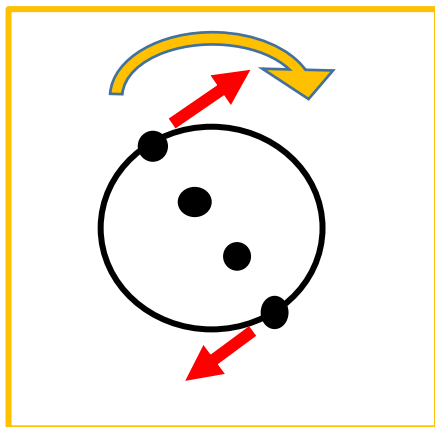
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## (((3 Makers of World's Smallest Machines Awarded Nobel Prize in Chemistry)))

Three pioneers in the development of **nanomachines, made of moving molecules,** were **awarded the Nobel Prize in Chemistry** on Wednesday. **Molecular machines, the world's smallest mechanical devices, may**

**eventually be used to create new materials, sensors and energy storage systems,** the Royal Swedish Academy of Sciences said in announcing the prize. "In terms of development, **the molecular motor is at the same stage as the electric motor was in the 1830s, when scientists displayed various spinning cranks and wheels, unaware that they would lead to electric trains, washing machines, fans and food processors,**" the academy said. The three scientists — Jean-Pierre Sauvage, J. Fraser Stoddart and Bernard L. Feringa — will share equally in the prize of 8 million Swedish kronor, or about \$930,000.

Why did they win? Nanotechnology — **the creation of structures on the scale of a nanometer, or a billionth of a meter —** has been a field of fruitful research for a couple of decades. Now, scientists are learning how to construct tiny moving machines about one-thousandth the width of a strand of human hair.



**INTRODUCTION:** These nano wheels have a radius of 2 nanometers ( $2 \times 10^{-9} \text{ m.} = r$ ). Given below in article is the nano wheel's frequency as  $f = 12 \times 10^6 \text{ rev./s.}$

**QUESTIONS:** (a) Find angular velocity ( $\omega = ?$ ) of nano wheel?  
(b) Find tangential velocity  $V$  of Nano wheel at outer edge?  
(c) Find linear distance traveled by outer edge of nano wheel over 5 minutes?

**HINTS:**  $\omega = 2\pi f$  ,  $v = r \omega$  ,  $x = v t$

**ANSWERS:** (a)  $75.4 \times 10^6 \text{ rad./s.}$   
(b)  $v = 0.1508 \text{ m./s.}$  ,  
(c)  $x = 45.24 \text{ m}$

Bernard L. Feringa, a professor of organic chemistry at the University of Groningen, in the Netherlands, was one of the three winners of the Nobel Prize in Chemistry, announced Wednesday, who were cited for their work in developing molecule-size machines.

Dr. Feringa, in 1999, became the first person to develop a molecular motor, creating a minuscule rotor blade powered by light that spun continually in the same direction. The first motor was not fast, but 15 years later, he and his research group demonstrated **one that spun 12 million times per second.** ( $f = 12 \times 10^6 \text{ rev./s.}$ )

**In 2011, they built a four-wheel-drive molecular "car." Four of the molecular motors acted as wheels, connected by a nano-chassis. In living organisms, nature has produced a slew of molecular machines that ferry materials around cells, construct proteins and divide cells.** Artificial molecular machines are still primitive by comparison, but scientists can already envision applications in the future.