What's Making NEWS in SCIENCE & TECHNOLOGY?

This is the tenth of 18 Newspaper in Education pieces designed to increase science literacy by stimulating interest in science and technology. For more information about NIE, call (860) 241-3847 or email nie@courant.com.

nie Hartford Courant.

Thermodynamics and Energy

Part III - The Second Law of Thermodynamics
By Lee Langston, Ph.D.

You've learned that the First Law of Thermodynamics deals with energy and its conservation: During a process involving a system and its surroundings, energy is neither created nor destroyed, but changed in form. This denies the possibility of creating or destroying energy.

The Second Law of Thermodynamics deals with *entropy*, a measure of disorder. Entropy analysis gives directions and restrictions on how energy transfers can take place. This second law denies the possibility of utilizing energy in particular ways.

The second law has such far-reaching consequences that it is difficult to cover in one simple statement. In fact, the instructor in a university thermo class may hand out three or four pages listing various statements of the second law!

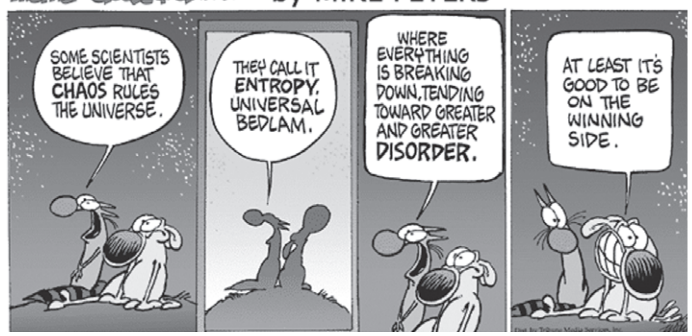
The second law's origin goes back to the 1800's and an engineering book by Sadi Carnot. Carnot set out to define the physical principles that could be used to understand and improve steam engines. The text discussed an *ideal* engine that operated between and high and low temperature (now called a Carnot engine), the efficiency of which all real engines could approach, but could not exceed. It sets a standard by which the performance of real engines is compared.

Building on Carnot's results, Lord Kelvin and Rudolf Clausius both arrived at statements for the second law.

- In 1882, Lord Kelvin wrote: "*It is impossible to construct an engine that, operating continuously, will produce no effect other than the extraction of heat from a single reservoir and the performance of an equivalent amount of work.*" If it *were* possible to build such an engine we could connect it to the ocean and, by extracting heat, produce all the power to, say, propel a ship, without needing any fuel!
- In 1865, Clausius wrote: "*It is impossible to construct a device that, operating continuously, will produce no effect other that the transfer of heat from a cooler to a hotter body.*" Heat will not, of itself, flow from a colder body to hotter body. A refrigerator can do this, but we must supply costly energy-electricity-to transfer heat from the cold food and drinks to the warmer kitchen air surrounding the refrigerator.

Clausius also identified a property he called *entropy*. Entropy changes can be calculated by measuring the heat transfer to or from a system during a process. Think back to the rubber band in Part II: In stretching, the entropy decrease of the rubber band is approximately equal to the heat transferred from the rubber band to its surroundings, divided by the air temperature. When the rubber band is relaxed, its entropy is *increased*, calculated in the same way.

MOTHER GOOSE & GRIMM by MIKE PETERS



Hartford Courant.

- COUNCIL FUNDS "GREEN" VEHICLES 1/23/2008
- RELL SIGNS ENERGY BILL 6/5/2007
- VOLUNTEERS OFFER ENERGY-EFFICIENT OPTIONS 12/6/2006

Entropy is a measure of molecular disorder. Stretching produced a more ordered, aligned arrangement of rubber band molecules. Relaxing allowed rubber band molecules to revert to their intercoiled, more disorganized (increased entropy) state.

Clausius determined: "*The entropy of the universe tends to a maximum*." In other words, all processes in life result in a net increase of entropy. You stretched the rubber band to decrease its entropy, but your (you being the rest of the universe) entropy increase caused by furnishing that stretching, exceeded that of the rubber band's decrease.

Still puzzled by entropy and disorder? Consider the Mother Goose rhyme on entropy production:

"Humpty Dumpty sat on a wall.
Humpty Dumpty had a great fall.
All the king's horses and all the king's men,
Couldn't put Humpty together again."

NIE thanks Lee Langston, Professor Emeritus of Mechanical Engineering, University of Connecticut; & Member, Connecticut Academy of Science and Engineering

TODAY'S QUOTE

"The law that entropy always increases – the second law of thermodynamics – holds I think, the supreme position among the laws of Nature." –Arthur Stanley Eddington (1882-1944)

THINK ABOUT THE QUOTE
- Rewrite the quote in your own words.
- What examples of entropy do you see in your daily life?

HOW DOES A GROUNDHOG CONSERVE ENERGY?

From the Connecticut Science Center

During hibernation, a groundhog's body temperature falls to about 6-9 degrees above freezing? By lowering its temperature and heartbeat and remaining dormant, the animal uses less energy as well as less of the body fat it stored. Hibernation is a sleep-like state during extreme cold weather conditions; estivation is a sleep like state during extreme heat. Some animals that live in the desert estivate to avoid the drought season.

Connecticut Science Center

A Vacation Sidetrip

You can never tell what a professor will do on vacation! While visiting Vienna, Dr. Langston and his wife ventured out to Ludwig Boltzmann's grave in the Central Cemetery. Boltzmann derived the equation for evaluating the entropy of gas. There, Dr. Langston was elated to see the famous Boltzmann relation, S=K log W, carved into the memorial stone!

SCIENCE, TECHNOLOGY & the NEWS

1. **Clip articles related to science and technology from today's newspaper.**
2. **Explain the difference between energy and entropy.**
3. **Describe an imaginary process that satisfies the First Law but violates the Second Law of Thermodynamics.**

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Want to know more? Find science and technology links and additional information at www.courantnie.com "SCIENCE LINKS"

"What's Making News in Science & Technology?" will appear again on Thursday February 28, 2008.