# Rock Doc:
# Three Laws We Don't Ever Break

**By Dr. E. Kirsten Peters**

I was surprised by how terribly hot the engine smelled.

On a recent Saturday I drove my '87 pickup truck home with a "new" camper on its back. I bought the camper for $800, about right for one built in 1975. I'm pleased (and surprised) to report the propane fridge and stove still work, so I was in high spirits as I started up the highway from the Snake River to the plateau where I live – some 1500 feet higher.

When I smelled the hot engine, I also instantly realized that I had no water with me. (You can trust a Ph.D. not to bring water when it would obviously be wise to do so.) I turned on the cab's heater to draw heat away from the engine, and pulled over repeatedly along the side of the highway to let the engine cool at idle. I made it to the top of the grade with a hot engine, hot legs, but no boiling-over.

Pulling over along the highway gave me plenty of time to reflect on why we physical scientists have studied and loved engines ever since Europe's first great energy crisis.

Here's the story:

By the mid-1600s, the good people of Great Britain were in serious trouble. They had, essentially, burned most of the wood they possessed in their cool and wet country. They were staying alive huddled over peat fires, but soggy peat is just about the world's worst fuel. Where could the Brits get the heat energy they desperately needed?

The answer lay under their feet. The British started to seriously mine coal, following the seams into hillsides and down into the Earth, with most all the work done by hand.

One problem with underground mining is that you have to get the "good stuff" up to the surface, which is a lot of work in itself. And you also have to pump water, 24-7, up and out of the mine so your miners don't drown before dinner. The British used both horse and human muscles to do all that hard work – until an ironmonger (no Ph.D. he!) had a much better idea.

Thomas Newcomen came to realize he could build a piston-driven machine that could use the heat from burning coal to do the most brutal labor of mining itself. His was the first modern steam engine, a special type of heat-to-work machine about the size of a small house. The power stroke came from atmospheric pressure, the kind of air pressure in which we all "swim" each day.

That engine, in time, was replaced by high-pressure steam engines you've seen in historic locomotives. These were heat-to-work machines so greatly decreased in size they could move around on a track, literally hauling the world into the modern era.

Pure science, which had been lagging behind during parts of this story, caught up quickly in the 1800s. Work and heat – which had been thought of as quite separate stuff – were soon understood to be forms of just one thing. The idea came to be named “energy,” a single concept that had not existed earlier. This was revolutionary physical science at its best. Soon, electrical and chemical energy were added to the list of forms of energy that can be transformed, one to another, but not created or destroyed.  That’s the often quoted First Law of Thermodynamics, a formal way of describing energy science.

Hauling my camper up 1,500 vertical feet of highway, my engine had to use a lot of heat from chemical energy (gasoline) to do a heck of a lot of work. And because, sadly enough, engines are only about 25 percent efficient, three-quarters of the gasoline’s heat ended up roiling out of the radiator and engine block – and on my bare legs.

The science of energy explains much of the natural world around us, from the biochemical reactions in your cells to what happens in high-tech electronics. But it was the study of desperately needed, if crudely constructed, heat-to-work engines that first led us to truly understand energy – the greatest and most flexible of all our resources.

Hats off to ironmongers!

Dr. E. Kirsten Peters is a native of the rural Northwest, but was trained as a geologist at Princeton and Harvard. A library of past Rock Doc columns is available at <www.rockdoc.wsu.edu>. This column is a service of the College of Sciences at Washington State University.