Friday 23 February 2006, 19th class meeting
(Miller Chapter 10, National Geographic [coal])

Environmental Biology (ECOL 206)
U. Arizona, spring 2006

Kevin Bonine, Ph.D.
Alice Boyle, Kristen Potter, Graduate TAs

1. Energy (Miller Ch. 10)

2. Lecture schedule updates on your website

3. 206 Lab Website for handouts and assignments
   Lab 21-24 Feb, Meet S side BSE (4th and Highland)
   Lab next week in the normal lab room (KOFL410)

4. Mt. Lemmon this weekend

Mt. Lemmon this weekend...

   Saturday 25 Feb
   Labs 1 and 2

   Sunday 26 Feb
   Labs 3 and 4

   Meet 0700h at S side of BSE (corner of 4th and Highland)
   “Be on time or get left behind.”
   Return around 1800h to campus

Please Bring:

Food (snacks and lunch)
   We will bring a cooler with ice for you to put stuff in if you wish.
Water (bring a small bottle, we will bring big jug for refills)
Hat
Clothes for variable weather conditions. Up top it might be in the 30s F and raining or snowing.
   Be prepared to enjoy yourself no matter the weather.

Small Notebook, Writing Instruments, Handout from 206 lab website
Sunscreen?
Binoculars?
Camera?
Money?

Please don’t bring personal music devices etc. We will be interacting as a group all day.
Pooches’ poo to help power Frisco
Arizona Daily Star
Published: 02.22.2006

Pooches’ poo to help power Frisco
THE ASSOCIATED PRESS

SAN FRANCISCO — City officials are hoping to harness the power of dog doo-doo. San Franciscans already recycle two-thirds of their garbage, but in this dog-friendly town, animal feces make up nearly 4 percent of residential waste, or 6,500 tons a year — nearly as much as disposable diapers, according to the city.

Within the next few months, Norcal Waste, a garbage hauling company that collects San Francisco’s trash, will begin a pilot program under which it will use biodegradable bags and dog-waste carts to pick up droppings at a popular dog park.

The droppings will be tossed into a contraption called a methane digester, which is basically a tank in which bacteria feed on feces for weeks to create methane gas. The methane could then be piped directly to a gas stove, heater, turbine or anything else powered by natural gas. It also could be used to generate electricity.

Methane digesters are nothing new. The technology was introduced in Europe about 20 years ago, and more than 600 farm-based digesters are in operation there. Nine are in use on California dairy farms, and chicken and hog farms elsewhere in the United States also use them.

Neither Norcal Waste spokesman Robert Reed nor Will Brinton, a Maine-based recycling and composting consultant, knew of anyone in the United States who is using the $1 million devices to convert pet waste to energy. But Brinton said some European countries process dog droppings along with food and yard waste.

“The main impediment is probably getting communities around the country the courage to collect it, to give value to something we’d rather not talk about,” Brinton said. “San Francisco is probably the king of pet cities. This could be very important to them.”

San Francisco — the city named after St. Francis, patron saint of animals — has an estimated population of 240,000 dogs and cats.
Energy (Ch 10)

- Solar 99% (not in market place)
- Commercial 1% (82% nonrenewable)
  (incl. indirect solar: wind, water, biomass)

Miller, 2003
Miller 2005, 10-2

Figure 8-2: Commercial energy use by source for the world (left) and the United States (right) in 2000. Commercial energy accounts for only 1% of the energy used in the world; the other 99% is direct solar energy received from the sun and is not sold in the marketplace. (Data from U.S. Department of Energy, British Petroleum, and Worldwatch Institute)

NonRenewable Energy

U.S. 4.6% population, 24% commercial energy
India 16% population, 3% commercial energy

Figure 8-1: Important nonrenewable energy sources that can be removed from the earth’s crust are oil, natural gas, and some forms of geothermal energy. Nonrenewable uranium ore is also extracted from the earth’s crust and then processed to increase its concentration of uranium-235, which can be used as a fuel in nuclear reactors to produce electricity.
U.S. Energy Sources

1. Availability
2. Net Energy
3. Costs to Develop
4. Subsidies, Tax Breaks
5. National Security
6. Terrorism
7. Environment, Climate, Human Health

![Net Energy Diagram]

Net Energy

1. Find
2. Extract
3. Transfer
4. Process
5. Transport
6. Burn

- 2nd Law of Thermodynamics

![Energy Efficiency Diagrams]

Energy Efficiency
Energy Efficiency

- Hybrid Cars
  Fuel Efficient and Battery
  80-300 miles/gallon

- Hydrogen Cells (cars etc.)
  \[ \text{H}_2 + \text{O}_2 = \text{energy} + \text{H}_2\text{O} \]

- Cogeneration (heat and power)
- Electric Motors

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U.S. Flow of Energy

- 2nd Law of Thermodynamics
Energy Sources

Solar – passive or active
Hydrogen - (green algae??) need to decompose water

Hydropower
Wind
Biomass
Geothermal

Fossil Fuels
Oil
Natural Gas
Coal

Nuclear

Figure 6-28: CO₂ emissions per unit of energy produced by various fuels, expressed as percentages of emissions produced by coal.
Fossil Fuels

Oil
Natural Gas
Coal

Advantages
- Ample supplies: (225–900 years)
- High net energy yield
- Low cost (with huge subsidies)
- Mining and combustion technology well developed
- Air pollution can be reduced with improved technology (but adds to the cost)

Disadvantages
- Very high environmental impact
- Severe land disturbance, air pollution, and water pollution
- High land use (including mining)
- Severe threat to human health
- High CO₂ emissions when burned
- Releases radioactive particles and mercury into air

Figure 6-30: Advantages and disadvantages of using coal as an energy resource.
Miller, 2003
(2005: 10-11)

Natural Gas

Advantages
- Ample supplies: (125 years)
- High net energy yield
- Low cost (with huge subsidies)
- Less air pollution than other fossil fuels
- Lower CO₂ emissions than other fossil fuels
- Moderate environmental impact
- Easily transported by pipeline
- Low land use
- Good fuel for fuel cells and gas turbines

Disadvantages
- Nonrenewable resource
- Releases CO₂ when burned
- Difficult to transport among countries
- Methane (a greenhouse gas) can leak from pipelines
- Shipped across ocean as highly explosive liquefied natural gas (LNG)
- Sometimes burned off and wasted at wells because of low price
- Requires pipeline distribution system

March 2006

The High Cost of Cheap COAL

NATIONAL GEOGRAPHIC
When you turn up the AC, think of Gibson and the grimy fuel it devours at the rate of three 100-car trainloads a day.

**WHO HAS COAL?** The world has more than a billion tons of readily available coal. The U.S. has the largest share, but other energy-hungry countries, such as China and India, are richly endowed as well.

<table>
<thead>
<tr>
<th>Country</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>27%</td>
</tr>
<tr>
<td>Russia</td>
<td>17%</td>
</tr>
<tr>
<td>China</td>
<td>13%</td>
</tr>
<tr>
<td>India</td>
<td>10%</td>
</tr>
<tr>
<td>Australia</td>
<td>9%</td>
</tr>
<tr>
<td>South Africa</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>19%</td>
</tr>
</tbody>
</table>

**WHO USES COAL NOW?** Global coal consumption is roughly five billion tons a year, with China burning the most. Western Europe has cut coal use by 36 percent since 1990 by using available natural gas from the North Sea and Russia.

<table>
<thead>
<tr>
<th>Country</th>
<th>Millions of Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1.531</td>
</tr>
<tr>
<td>Russia</td>
<td>1.117</td>
</tr>
<tr>
<td>India</td>
<td>1.094</td>
</tr>
<tr>
<td>U.S.</td>
<td>431</td>
</tr>
<tr>
<td>Europe*</td>
<td>251</td>
</tr>
<tr>
<td>Other</td>
<td>1,016</td>
</tr>
</tbody>
</table>

**WHO WILL USE IT TOMORROW?** China’s coal needs will more than double by 2030 to satisfy factories and consumers. The country also plans to convert coal to liquid motor fuels. Worldwide, consumption will rise by 56 percent.

<table>
<thead>
<tr>
<th>Country</th>
<th>Millions of Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>3,242</td>
</tr>
<tr>
<td>U.S.</td>
<td>1,595</td>
</tr>
<tr>
<td>Europe*</td>
<td>853</td>
</tr>
<tr>
<td>India</td>
<td>733</td>
</tr>
<tr>
<td>Russia</td>
<td>228</td>
</tr>
<tr>
<td>Other</td>
<td>1,002</td>
</tr>
</tbody>
</table>

* Excluding Russia

**U.S. ELECTRICITY GENERATION**

<table>
<thead>
<tr>
<th>Source</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>50%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>20%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>19%</td>
</tr>
<tr>
<td>Renewables</td>
<td>9%</td>
</tr>
<tr>
<td>Oil</td>
<td>3%</td>
</tr>
</tbody>
</table>

**U.S. POWER PLANT CO₂ EMISSIONS**

<table>
<thead>
<tr>
<th>Source</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>83%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>13%</td>
</tr>
<tr>
<td>Oil</td>
<td>4%</td>
</tr>
</tbody>
</table>

**WHAT'S IN COAL SMOKE?**

- **SULFUR DIOXIDE**: The sulfur in coal forms this gas, which gives rise to acid rain when it reacts with water in clouds. Many plants control sulfur emissions by burning low-sulfur coal and passing the exhaust through scrubbers, which capture sulfur dioxide.

- **NITROGEN OXIDES**: The heat of power-plant burners turns nitrogen from the air into nitrogen oxides, which can contribute to acid rain and ground-level ozone. Pollution controls on many plants limit nitrogen oxide emissions.

- **MERCURY**: The traces of mercury in coal escape in power-plant exhaust. Falling hundreds of miles away in rain or snow, the mercury builds up in fish, making some species unsafe for children and pregnant women to eat.

- **CARBON DIOXIDE**: Coal produces more CO₂ per energy unit than any other fossil fuel. CO₂ is a greenhouse gas, affecting climate by trapping heat that would otherwise escape to space. Power plants today release all their CO₂ into the atmosphere.

- **PARTICULATES**: Particles from coal-burning plants can harm people who have heart and breathing disorders. Soot and ash are captured before they go up the stacks, but finer particles can form borax, from oxides of sulfur and nitrogen.
Fossil Fuels
- Oil
- Natural Gas
- Coal

Arctic National Wildlife Refuge (ANWR)
- 1/5 land in wildlife refuge system
- 19% chance of finding enough oil to supply U.S. for 24 months
- Persian Gulf oil cheaper
- Fuel efficiency better route
- Lots of oil spills likely
- Pipelines vulnerable
- Fragile tundra
- Impact acreage

Figure 6-16: Advantages and disadvantages of using conventional oil as an energy resource.

Miller, 2003 (2005: 10-6)
Fossil Fuels

Subsidized!

- Foreign military intervention
- Terrorism
- Habitat destruction
- Oil spills
- Health care (smog, accidents, poor fitness)
- Climate change (sea level, global warming)
- etc.

> $300 billion/year

= $600 billion/year

Costs not included:

- Price of Gas

Precautionary Principle

Study: Gasoline additive MTBE easily absorbed
A Shade of Green: S.U.V.’s Try to Soften Image

BY DANNY HAKIM

DETROIT, Feb. 15 — Can the sport utility vehicle, the bête noire of environmental advocates, be reinvented as a green machine?

This year, Ford and Toyota plan to release the first two hybrid sport utility vehicles. With careful mileage expected, the advent of the hybrid S.U.V. may change the uniformly vitriolic attitude of sport utility vehicles among environmental advocates, even if automakers are unlikely to sell enough hybrids to significantly reduce fuel consumption or pollution any time soon.

“I would definitely encourage people who need four-wheel-drive vehicles to look at these,” said the Rev. Jim Wallis, the president of the Evangelical Environmental Network, a small group that sponsored a widely publicized grass-roots campaign called “What Would Jesus Drive?”

“These vehicles are one small step,” he added, “but we’ve got a long way to go here.

The Toyota and Ford hybrids, which will be 2005 models, supplement the internal combustion engine with an electric motor that kicks in at stop-and-go speeds and at stoplights, a switch that they say can help S.U.V.’s get 27 to 30 miles a gallon.

Brazil Political Scandal

President Luiz Inácio Lula da Silva of Brazil is coming under increasing pressure over a corruption scandal involving a member of his government, who the party he founded.

DeLay Committee Inquiry

Prosecutors are said to have won a key victory in Texas with the arrest of Representative Tom DeLay, the House majority leader.

Concern Over Avian Flu

An outbreak of avian flu at a chicken farm in Delaware has raised concerns about the disease worsening in the birthplace of America’s chicken industry.

Knicks Make Another Trade

The Knicks traded Keith Van Horn to Milwaukee in exchange for Tim Thomas and Nazr Mohammed in a deal that also involved Atlanta.

Hydrogen as fuel

Crystals Could End Up as the Fuel Tank of the Future

At first glance, the crystal looks like glass. But to Dr. Gregory M. Vassegh, a professor of chemistry at the University of Michigan, the crystal is a solid that weights about a thousandth of an ounce. To him, it looks like a small molecule would resist a strong charge of electricity. The molecules are arranged in such a way that they can barely be seen.

That is why Dr. Vassegh said, “This is the only thing that’s worth using for storing fuel — hydrogen, in particular.

The compound is known as polyacrylonitrile, known as PAN, and it is used to make fibers.

Practical hydrogen storage in a manageable size.

By adding hydrogen to the surface area of a carbon nanotube, researchers have created a new type of battery.

Like adding shelves to a closet

Tiny crystals with surfaces similar to those of nanotubes have the potential to store hydrogen.

The researchers found that they could fill a NOS-17 crystal with hydrogen molecules, known as hydrides. They showed that the process could be repeated.

NOS-17 is a carbon nanotube, a tube made of carbon that is only one atom thick, and it is made of carbon nanotubes that are 100 nanometers in diameter.

Hydrogen and other molecules are stored in the space above the surface, creating a new way to store hydrogen.

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Nuclear Energy

Accidents catastrophic sabotage?

Chernobyl, Three-Mile Island

What to do with Radioactive Waste?
- 10k-240k years
- bury it (ground)
- bury it (ice)
- bury it (ocean)
- shoot into space
- descending subduction zones

Yucca Mountain, NV
- leaks, faults, volcanoes
- 6 shipments/day for 30 years

Nuclear Weapons

Yucca Mountain Potential Leaks...

Experts warn of N-leaks at Yucca Mtn.
Yucca Mountain

- Number of people in Arizona that live within 1 mile of a nuclear transportation route - 448,024

- Schools within 1 mile of the proposed route in Arizona - 212

- Hospitals within 1 mile - 11

- Fatal tractor-trailer wrecks in Arizona 1994 to 2000 - 513

- Train wrecks in Arizona 1990-2001 - 762

- Nuclear waste shipments in Arizona over the life of the project:
  - If by truck: 102,018
  - If by train: 13,078

- Nuclear waste in Arizona now - 1,045 metric tons. Nuclear waste in Arizona if Yucca Mt. Project proceeds to completion - 1,899 metric tons.

The Department of Energy’s worst-case scenario predicts 48 radiation-induced deaths in a terrorist incident and 5 radiation-related deaths in a serious truck accident. Other experts estimate thousands of deaths over time if the release is in an urban area. First responders, local police, fire and hazardous materials response teams could easily be exposed to lethal doses of radiation. Billions of dollars and many years could be required to clean up the area. Transportation routes, including major interstates and train lines could be closed for months.

“The important thing now is to recognize that there is no immediate crisis, that there is time to do this and to do a good and responsible job in terms of safety and security and to do it at a much lower cost to ratepayers.” -- Former Nuclear Regulatory Commission, Commissioner Victor Gilinsky, testimony before the U.S. Senate Energy and Natural Resources Committee hearing, May 22, 2002.
What to Do??

- Free Market, Subsidy, Tax
- Efficiency
- Renewable
- Include all costs in analyses

Figure 6-30: Solutions: suggestions that various analysts have made to help make the transition to a more sustainable energy future.

Miller, 2003 (2005: 10-40)
Tuesday, February 21
Biological Evolution: What It Is and What It Isn't
Joanna Masel, Assistant Professor, Ecology and Evolutionary Biology

Tuesday, March 7
Cosmic Evolution: From Big Bang to Biology
Chris Impey, Distinguished Professor, Astronomy

Tuesday, March 21
Earth Evolution: The Formation of Our Planet
Joaquin Ruiz, Dean of the College of Science and Professor of Geosciences

Tuesday, March 28
Social Evolution: Cooperation and Conflict from Molecules to Society
Rick Michod, Professor, Ecology and Evolutionary Biology

Tuesday, April 11
Animal Evolution: Recycling Ancient Genes for New Uses
Lisa Nagy, Associate Professor, Molecular and Cellular Biology

Tuesday, April 18
Human Evolution: Tracing Our Origins with DNA
Michael Hammer, Research Scientist, Division of Biotechnology and Department of Ecology and Evolutionary Biology

Tuesday, April 25
Disease Evolution: The Example of HIV
Michael Worobey, Assistant Professor, Ecology and Evolutionary Biology

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