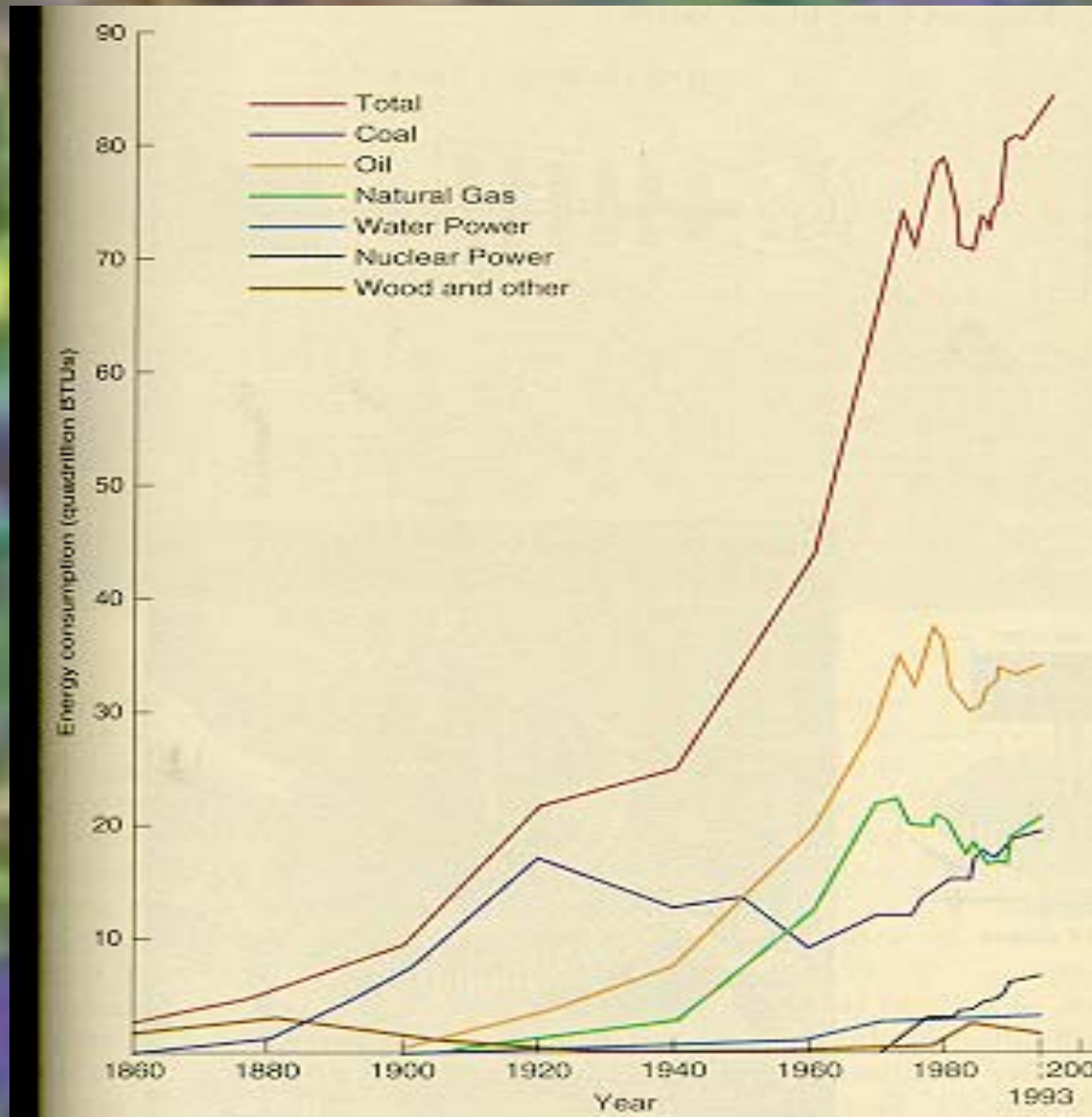




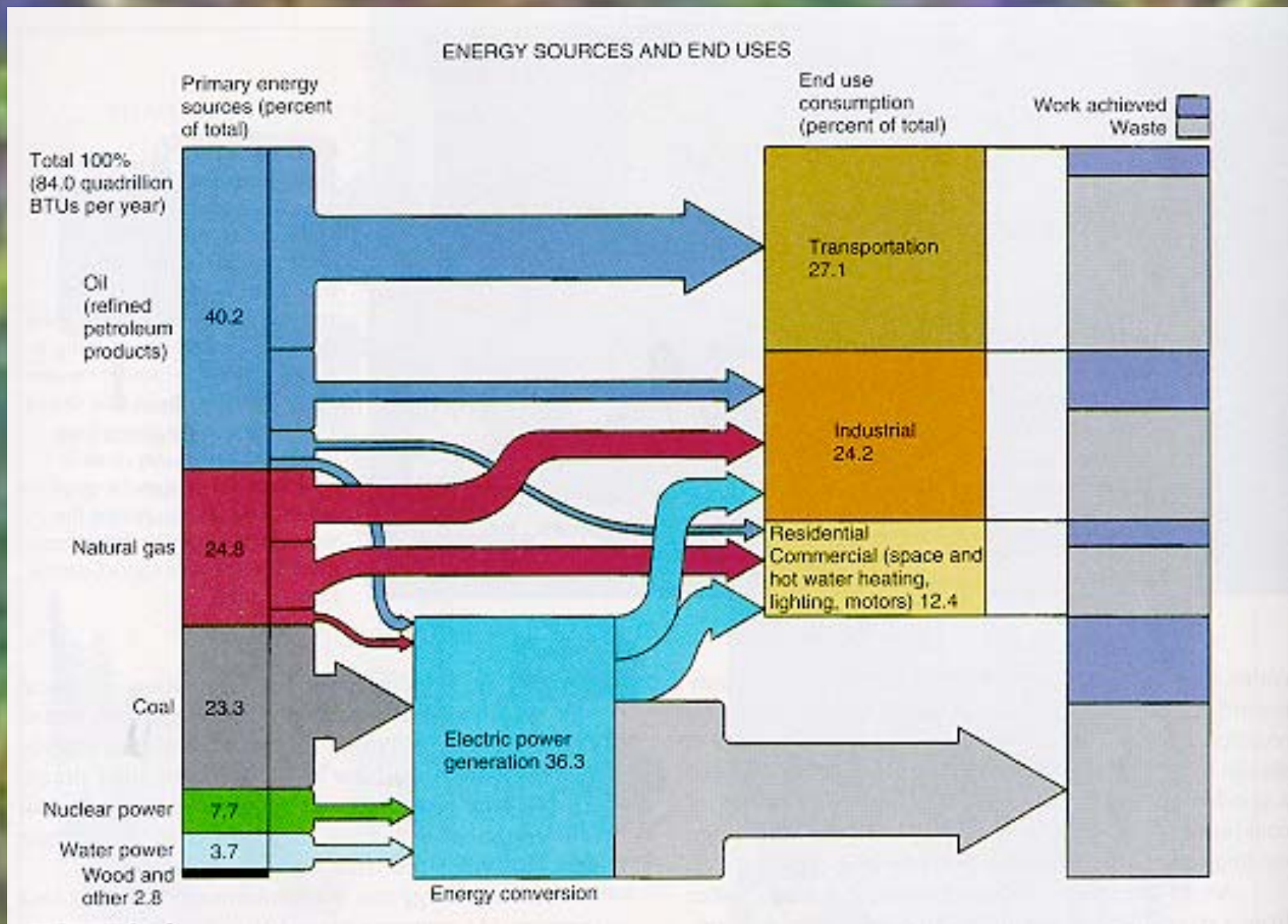
Nonrenewable Energy

THE BAD NEWS?

History of Energy Consumption



Where do energy resources go?



Types of Nonrenewable Energy



Fossil fuels

Crude Oil

Coal

Natural Gas



Nuclear Energy

How are fossil fuels formed?

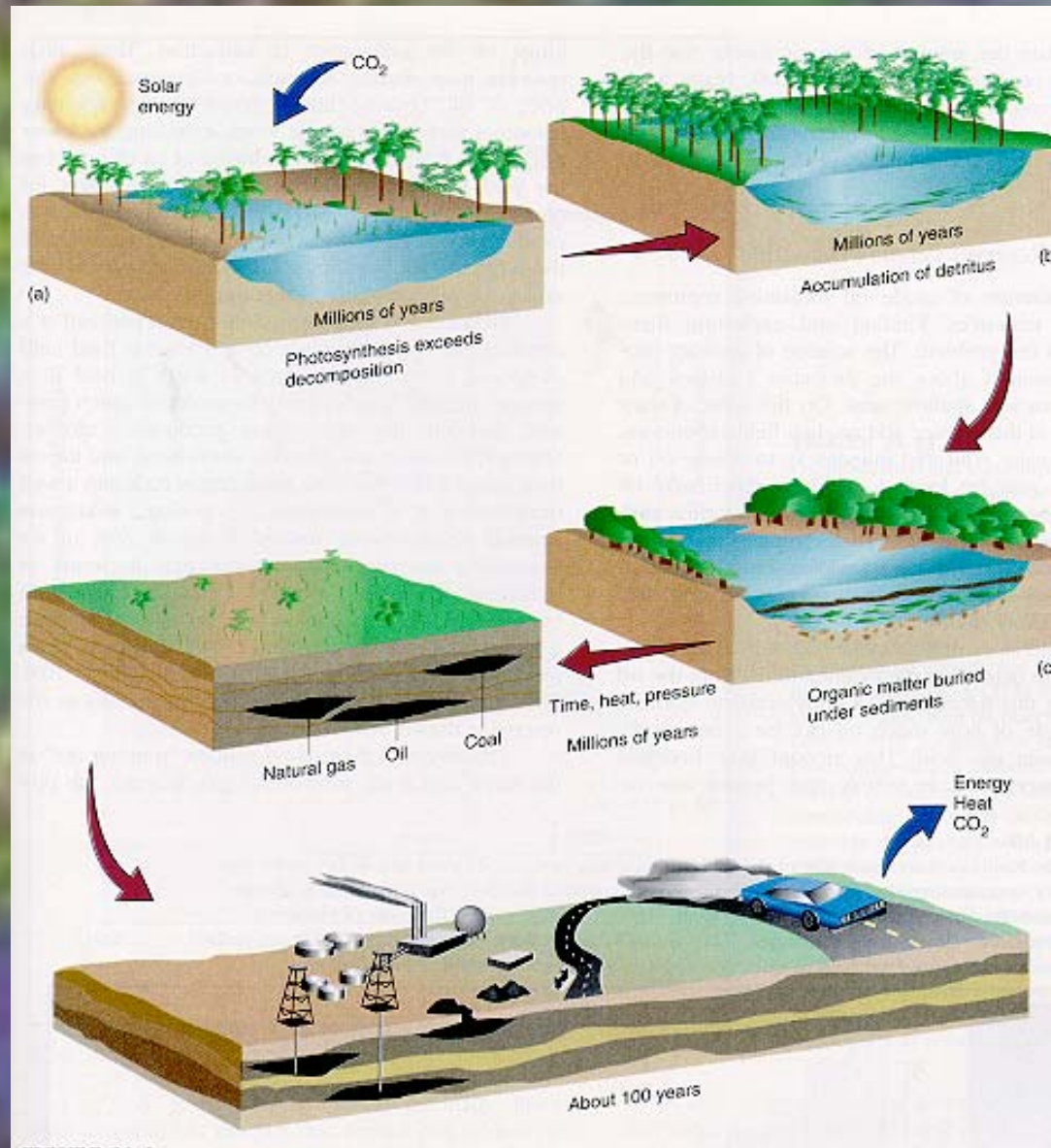


FIGURE 21.9

Where are fossil fuels found in North America?





COAL

Coal

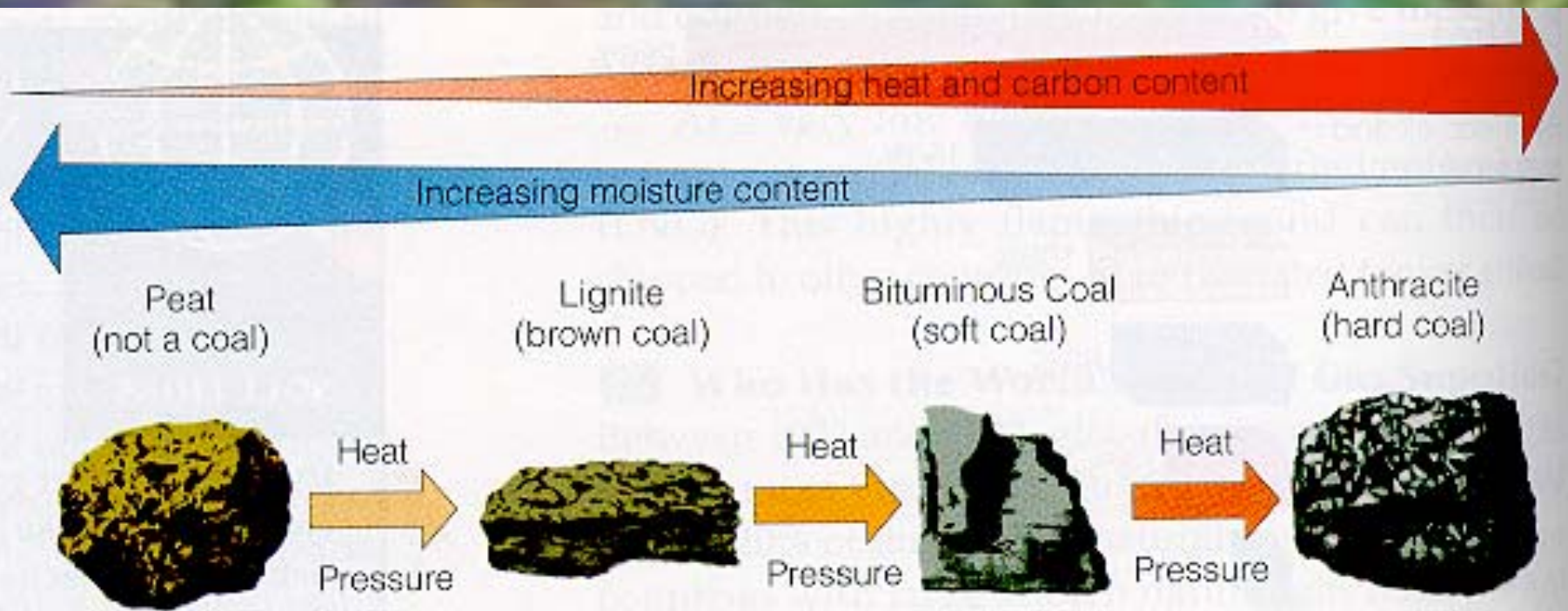
Coal is a rock that is formed in the Earth in several stages

- Buried remains of plants in Carboniferous period (280mybp) are subjected to heat and pressure
- over time, sulfur is gradually incorporated into the coal as it forms
- Coal is mostly carbon, with some water and sulfur

Three types of Coal

- Peat (not a coal) is beginning stage
- Lignite - brown coal, low heat and sulfur content, limited supplies
- Bituminous - soft coal, most commonly used, high heat content, large supplies, high sulfur
- Anthracite - hard coal, high heat content, takes longest to form, expensive, fewer supplies, low sulfur

Formation of Types of Coal



Extraction of Coal: Mining

- Strip Mining - surface mining in which overlying layer of soil and rock is stripped off to reach coal - most common
 - Very destructive to the environment because large amounts of topsoil are removed
 - precipitation combines with spoil banks to make sulfuric acid which pollutes water
- Subsurface Mining - 40% of mining in U.S.
 - very dangerous (black lung, etc.)
 - labor intensive (requires 5x more workers)
 - acid drainage, land subsidence

How is Coal Used?

- 25% of world's commercial energy
- used to generate 39% of world's electricity
75% of world's steel
- China is world's largest consumer (76% of their energy)
- Coal supplies 57% of the U.S. electricity

How can coal be used to generate electricity?

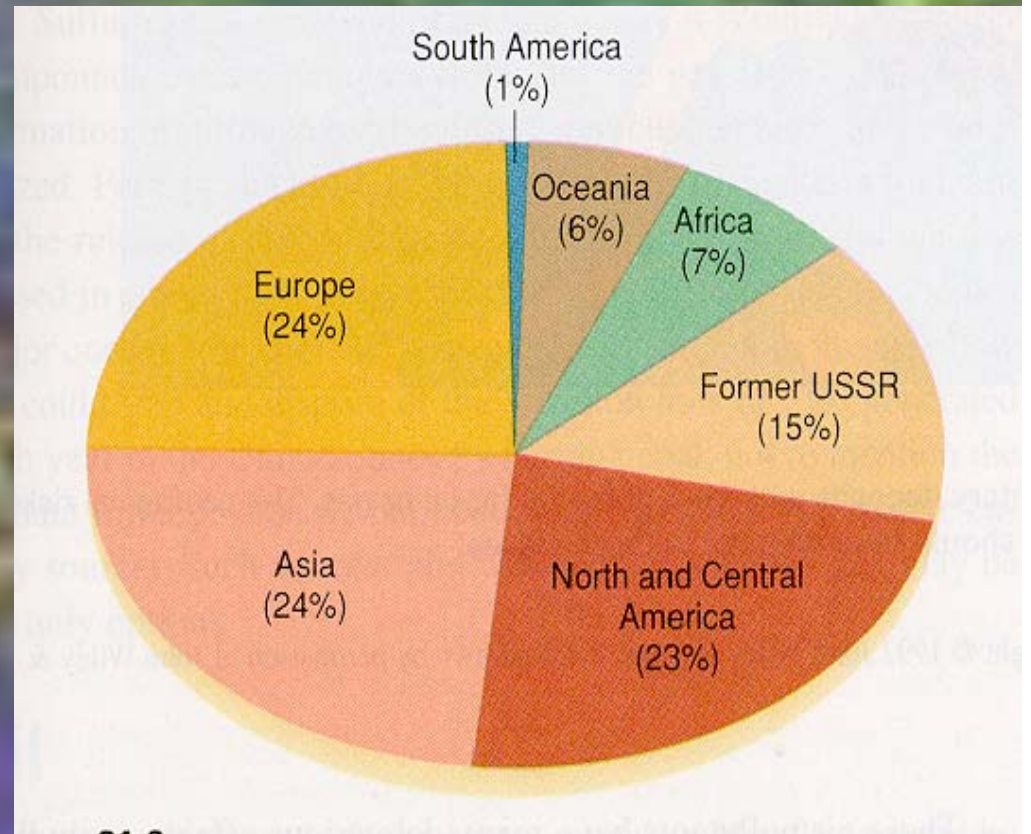
- Coal is ground into a fine powder (increase surface area) and burned at a high temperature
- Steel pipes filled with water run through the fire producing high pressure steam
- The steam is used to turn a turbine
- The turbine spins a generator which produces electricity

Conversion to Gaseous and Liquid Fuels

- Coal liquefaction - conv. to methanol
- Coal gasification - conv. to synthetic natural gas or hydrogen gas
- lower air pollution, BUT
- low energy yield because energy is lost in conversion
- would increase use of coal because 30-40% of energy is lost in conversion
- more mining

Location of remaining coal reserves

- Identified oil reserves should last at least 220 years at current usage levels, but only 65 years if current usage increases 2% per year
- Unidentified sources will last 900/149 years





Pros of Coal Use

- Quite abundant
- High net energy yield
- China has the worlds largest supply

Cons of coal use

- environmental effects of extraction (loss of soil, subsidence)
- extraction is dangerous (black lung)
- water pollution
- air pollution
- production of CO₂



OIL



Three sources of oil

- Crude oil from underground deposits
- Oil from Oil Shale
- Oil from Tar Sands

Crude Oil

- Definition:
 - produced by the decomposition of deeply buried organic material from plants and animals under high temperatures and pressures over millions of years.
- Natural gas and crude oil are found together

Crude oil recovery



Primary Oil Recovery

- drilling a well and pumping out oil that flows by gravity into the well



Secondary Oil Recovery

- injection of water into nearby wells to force the heavy oil into the well

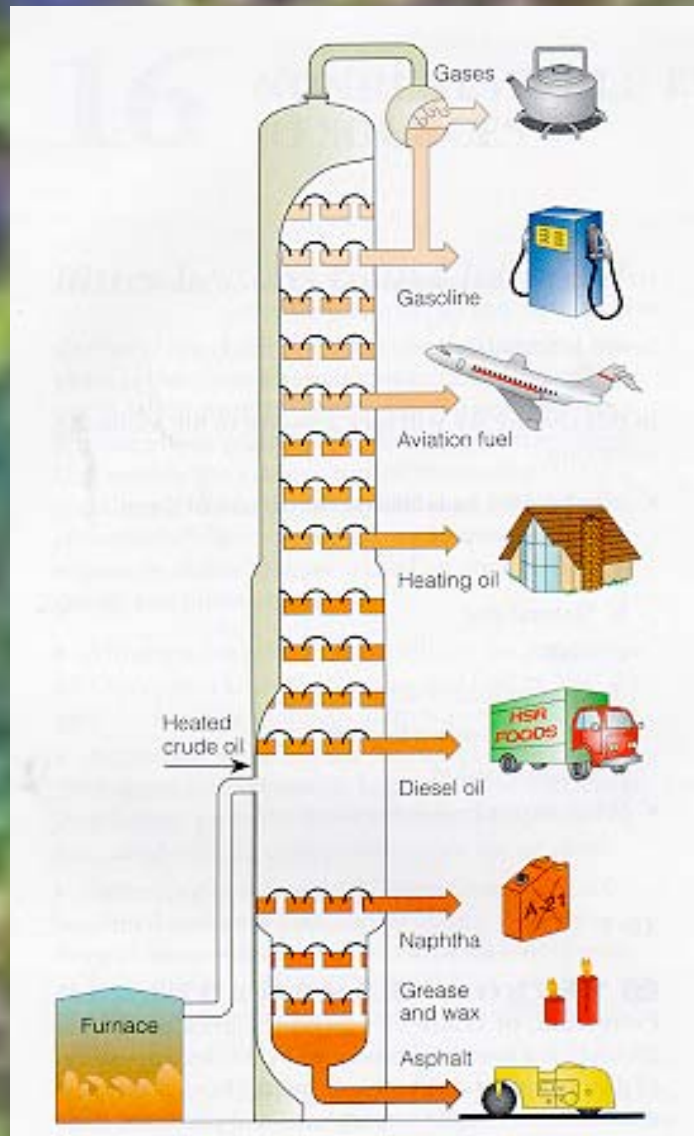


Tertiary Oil Recovery

- injection of steam or CO₂ into wells to force oil out

Average yields are only 30-50% at which time it becomes too expensive to extract more

How is crude oil refined?



- Crude oil is a mixture of many different hydrocarbons that can be separated with distillation
- From heaviest to lightest: asphalt, wax, naphtha, diesel oil, heating oil, jet fuel, gasoline, cooking gases (propane, butane)



Pros of Conventional Oil

Cheap

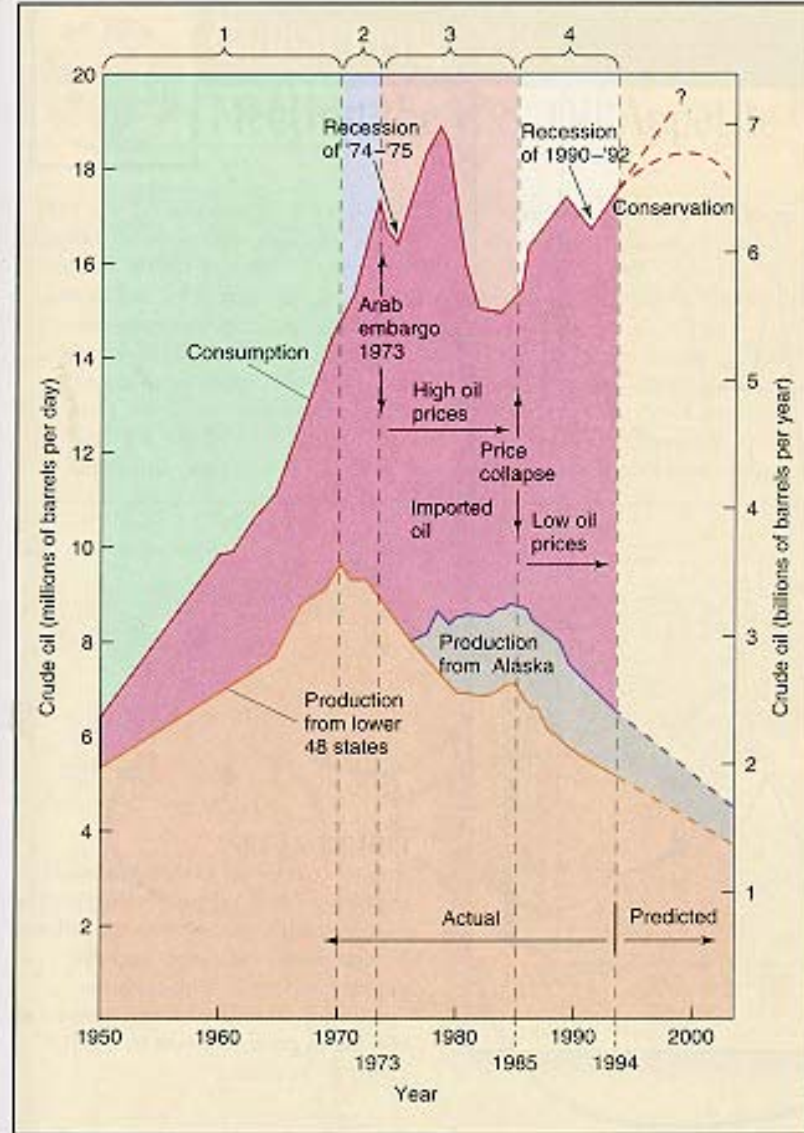
Easily transported

High net energy yield

Cons of Conventional Oil

Reserves are limited

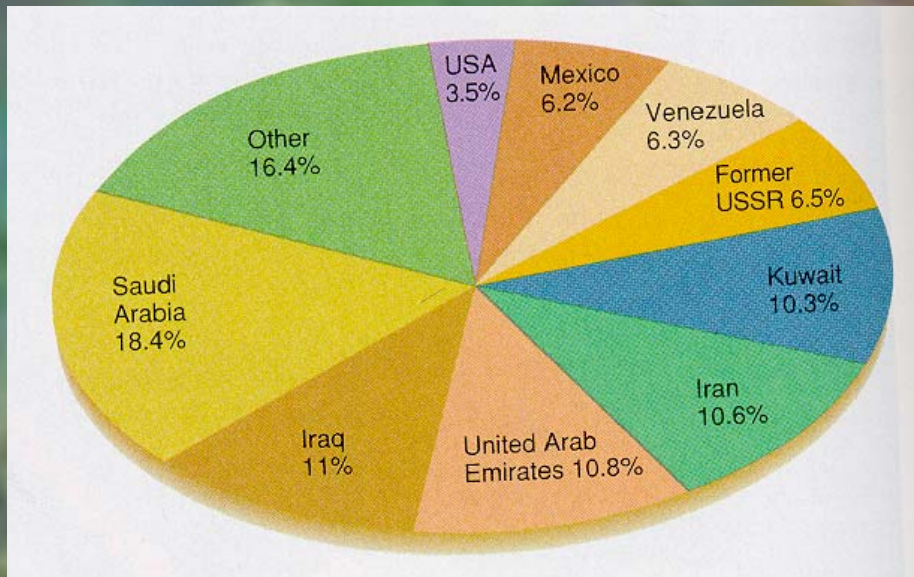
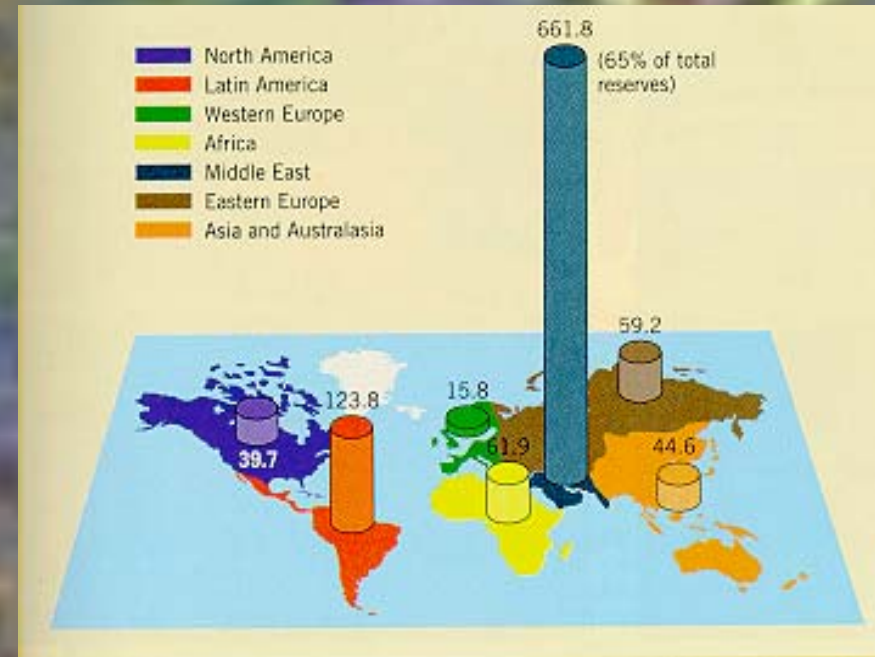
In U.S. we import more than we produce, causing our dependence on oil producing countries (Gulf War)



Cons of Conventional Oil

Where the remaining reserves are:

- 18% Saudi Arabia
- 11% Iraq
- 11% Iran
- 11% UAE
- 10% Kuwait



• World reserves may be 80% depleted in 44-84 years depending upon usage

Gulf War



- In the Gulf War, the Iraqis burned 10% of Kuwait's oil fields as they retreated

Cons of Conventional Oil (cont)

- It will become more and more expensive to extract remaining reserves
 - We will be forced to return to less productive, or mostly empty wells
- The burning of conventional oil produces CO₂
- Mining degrades the land and causes erosion
- Transportation and off-shore drilling cause spillage into waters

Shale Oil

- Oil Shale - fine grained rock that contains a mixture of hydrocarbon compounds called kerogen
- Once brought to the surface, the shale can be crushed and heated, vaporizing the kerogen.
- The kerogen vapor is then condensed to make shale oil

Pros and Cons of Shale Oil

Pros:

Huge resource- could meet the country's needs for oil for 41 years at current usage levels.

Reserves of oil shale may be 200x greater than reserves of crude oil

Cons:

Low energy yield (takes the energy of 1/2 a barrel of crude oil to get one barrel of shale oil.

Requires large amount of water in dry areas where rock is found.

Burning produces CO₂

Tar Sands

- Tar Sand - mixture of clay, sand, water and bitumen (a high sulfur oil)
- The bitumen is removed by heating the sand until the bitumen softens and floats to the surface
- Then it is refined into traditional crude oil

Pros and Cons of Tar Sands

Pros:

HUGE resource (Canada has 270 bil m³)
-worlds largest known oil deposits

Cons:

Low energy yield (same reasons as shale oil)

Production of toxic sludge and requires lots
of water

Refining produces air pollution

Burning produces CO₂

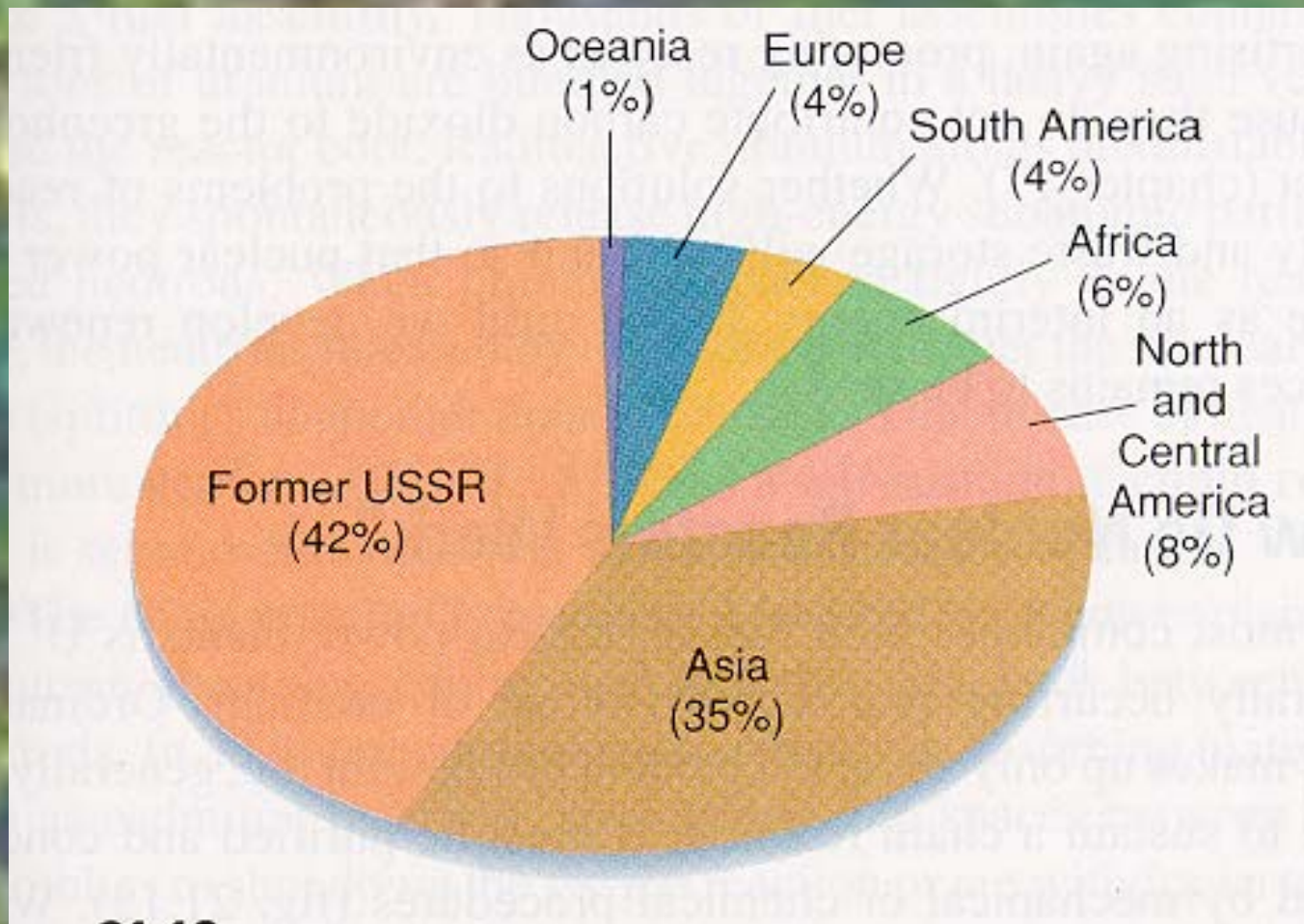


NATURAL GAS

Overview

- Natural Gas is the third most important fuel making up 24% of world's consumption
- It is mixture of 50-90% methane and small amounts of ethane, propane butane and hydrogen sulfide
- conventional N.G. - lies on top of crude oil
- unconventional N.G. - on top of coal, dissolved in water, underground sands; unconventional sources have promise in future because of abundance.

Who has natural gas?



Pros of Natural Gas

- Pros:
 - abundant, cleaner burning (50% CO₂ of coal)
 - cheaper than oil
 - reserves should last 80-200 years at current levels
 - can be transported easily over land by pipeline
 - high net energy yield
 - extraction doesn't damage the environment so much as coal or uranium ore
 - easy to process
 - can be used to power vehicles

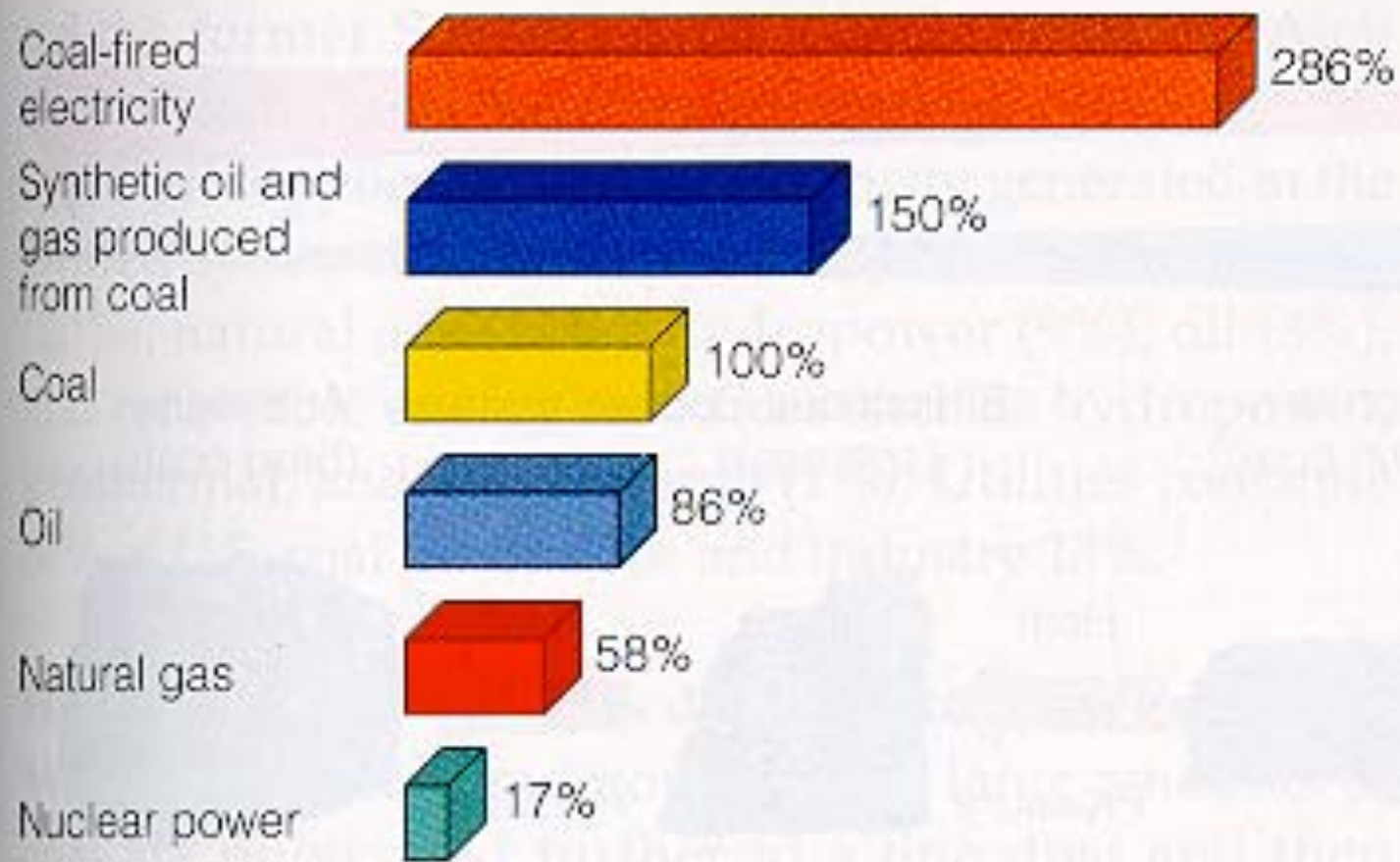
Cons of Natural Gas

- Some toxic sulfur gases are produced
- must be converted to liquid form before transport
- leakage into air can increase global warming
- **OVERALL:** considered to be the best fuel in our conversion to renewable energy sources

Unfortunately, we have lost a lot of natural gas due to carelessness



Downside of all fossil fuels: Production of CO₂



The background of the slide is a blurred, multi-colored image. It features a mix of green, blue, purple, and brown tones, suggesting a globe or a complex, abstract pattern. The colors are soft and out of focus, creating a textured, artistic backdrop for the text.

NUCLEAR ENERGY

Overview

- Nuclear energy currently amounts to 24% of the electricity in the U.S.
- Energy is created through a controlled nuclear reaction which is used to boil water and power a generator
- A huge amount of energy can be created, but fuel is not renewable, and dangerous wastes are created

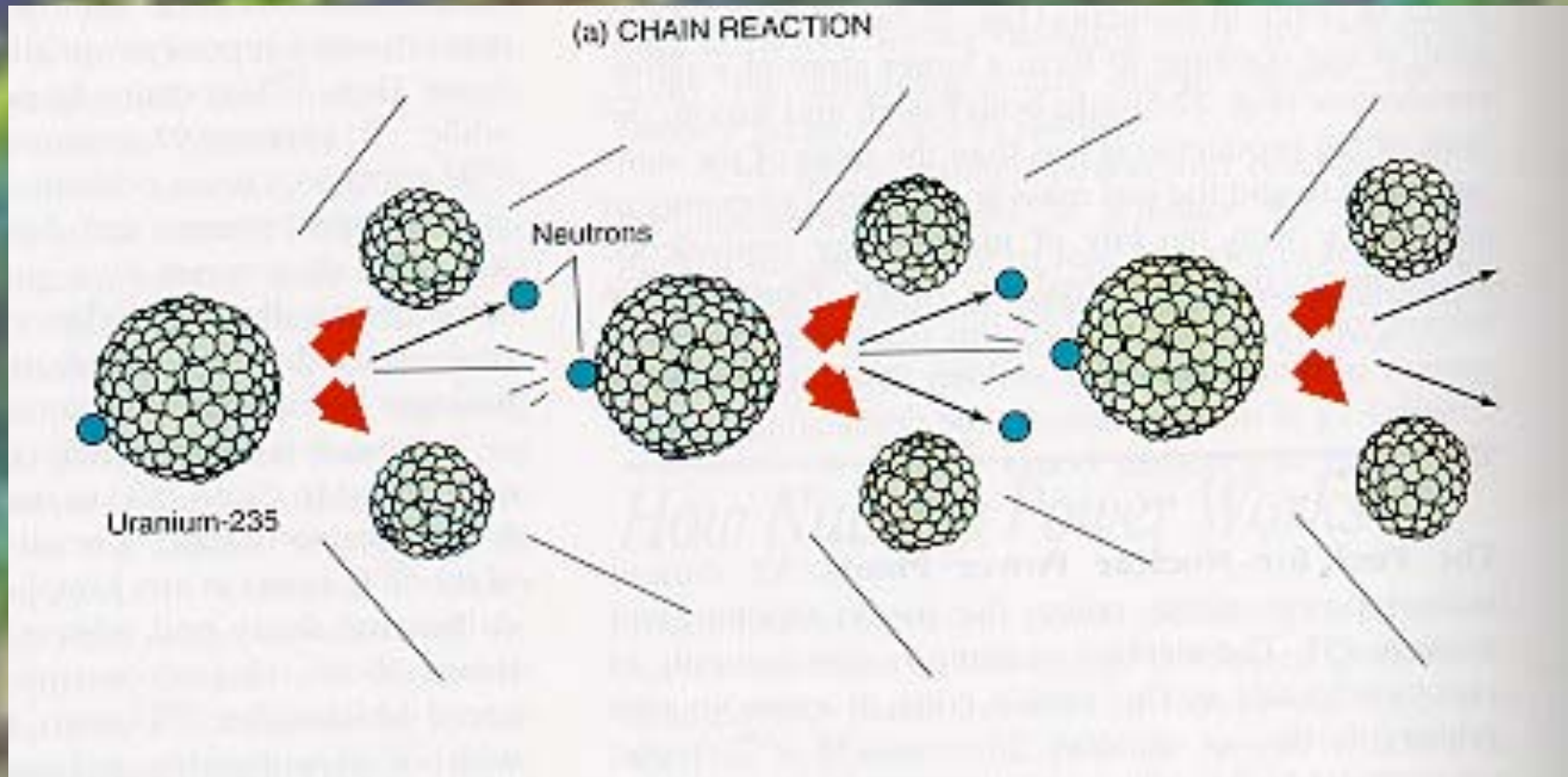
Radioactivity

- Naturally occurring radioactive isotopes of atoms are unstable, and “decay”.
- During decay, the atoms spontaneously change from one type into another until a stable isotope of an atom is formed.
- In the process, three types of radiation are given off
 - alpha particles (He nuclei - $2P, 2N$)
 - beta particles (high energy electrons)
 - gamma radiation (high energy waves)
- Radioactive decay of elements occurs at a predictable rate described by a half-life.

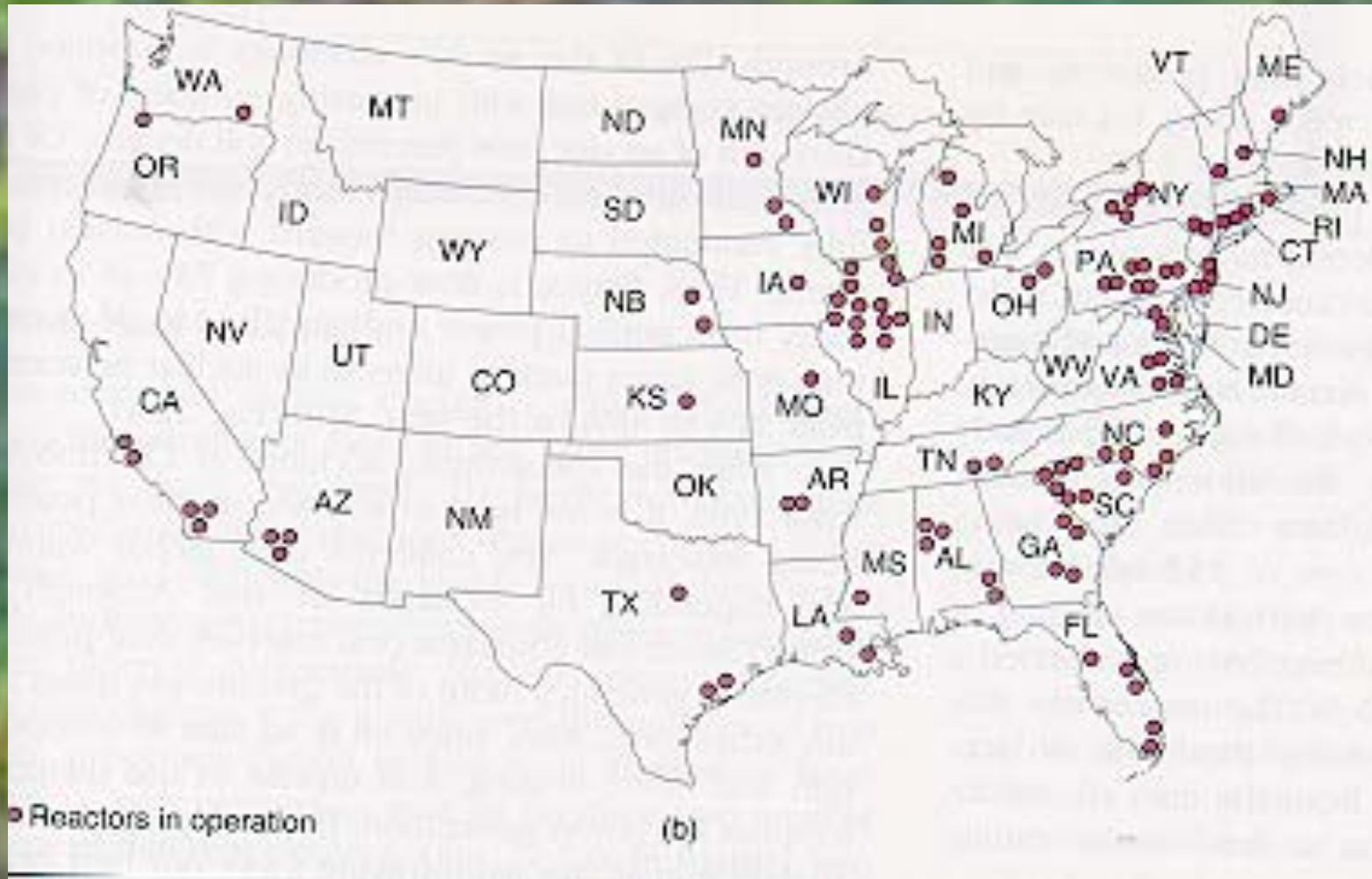
Nuclear fission

- Nuclear fission is the process of splitting large, radioactive atoms into smaller atoms and fragments
- As each atom decays, it produces neutrons, smaller nuclei and energy. The neutrons can cause neighboring nuclei to decay
- A “critical mass” of radioactive atoms is needed to produce a chain reaction.

Fission example



Where are nuclear reactors?

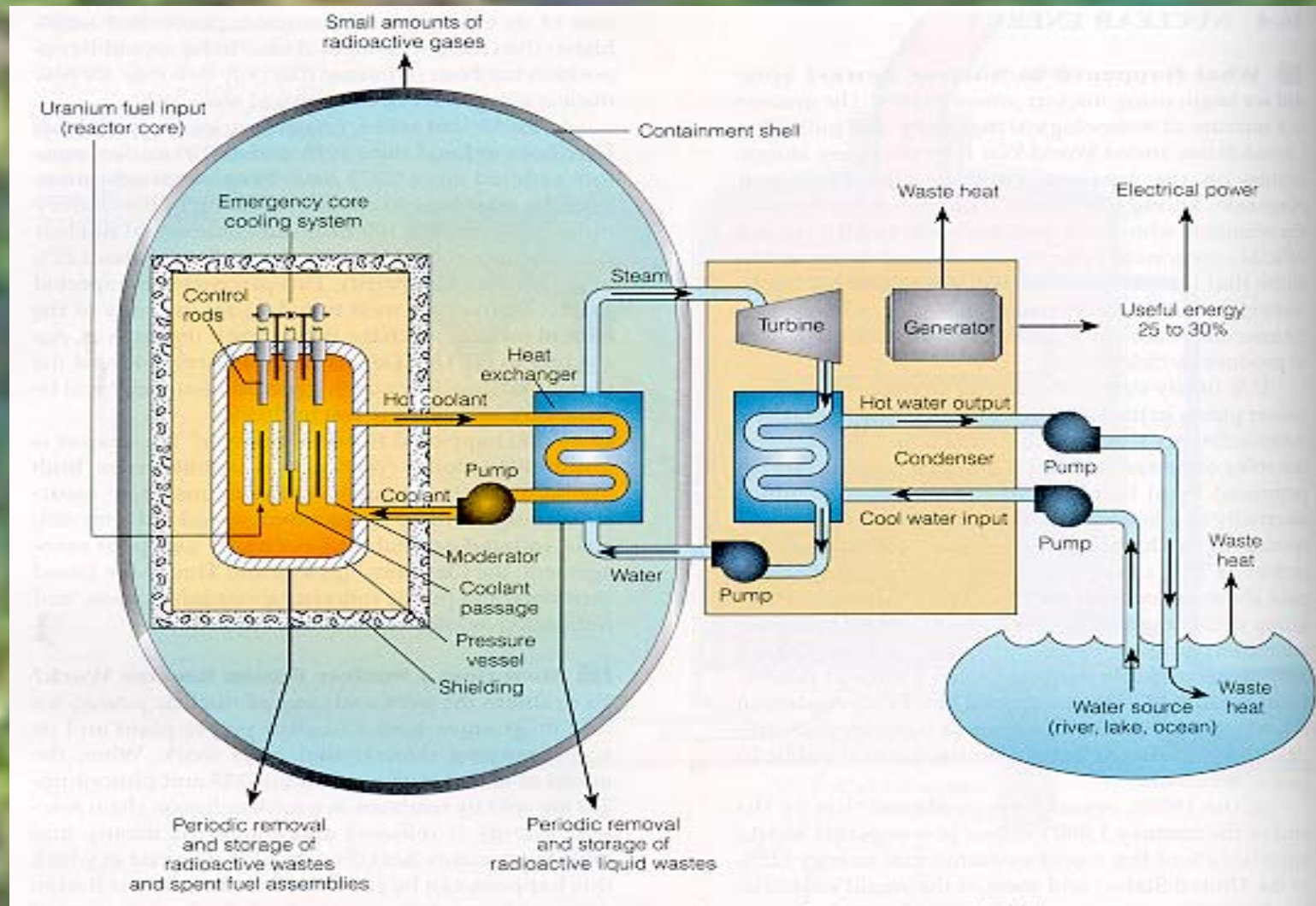


How Do Reactors Work?

- The most important isotope used in reactors is U-235.
- U-235 exists in all uranium ore, but only .7% of all ore is U-235.
- U-235 is processed (enrichment - raises level of U-235) to form UO_2 which is used as fuel

How Reactors Work

- Light-water reactors (LWRs)



LWRs

- Core
 - fuel rods (12ft) arranged in a diamond shape (15x15)
 - control rods - absorb neutrons and slow reaction down
 - water - keeps core cool(coolant), slows down the neutrons so that they are at the right speed to trigger the next reaction (moderator) and produces steam to make electricity
- high pressure steam from reactor is used to heat water which then produces steam used to run a turbine

LWRs

- cold water from a local source is used to condense the steam, and that warm water is returned to the environment (thermal pollution)
- fuel rods last about 3-4 years, so every year, about 1/3 of the rods are replaced

LWRs: wastes

- The products of nuclear reactions are also radioactive
- Some of the products have short half-lives and need only be stored for a short time (1000 years). Others have half-lives close to 10,000,000 years, and must be safely stored a minimum of 10,000-250,000 years (maybe more!)

Low-level wastes

- Wastes that give off small amounts of radiation
- must be stored safely for 100-500 yrs
- Most in the U.S. are put in steel drums and dumped into the ocean, others are put in landfills
- Landfills leak, so there are protests against building new ones--Joshua Tree

High-level wastes

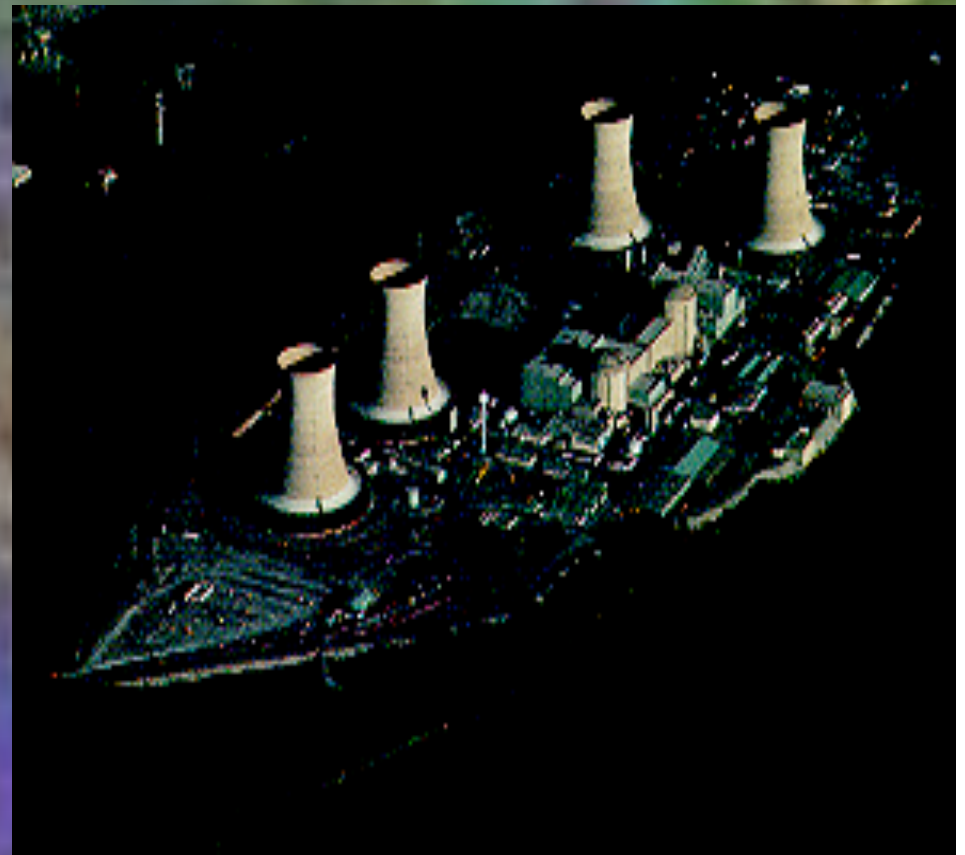
- Waste that gives off high amounts of radiation for a short time, or low amounts for a long time
- Spent fuel rods and wastes from making bombs
- Plans:
 - bury it : most popular - Yucca Mountain
 - shoot it into space
 - bury under ice sheet
 - bury under mud in oceans
 - break it down
- We currently accept high-level wastes from other countries

Nuclear Power Plants: Safety

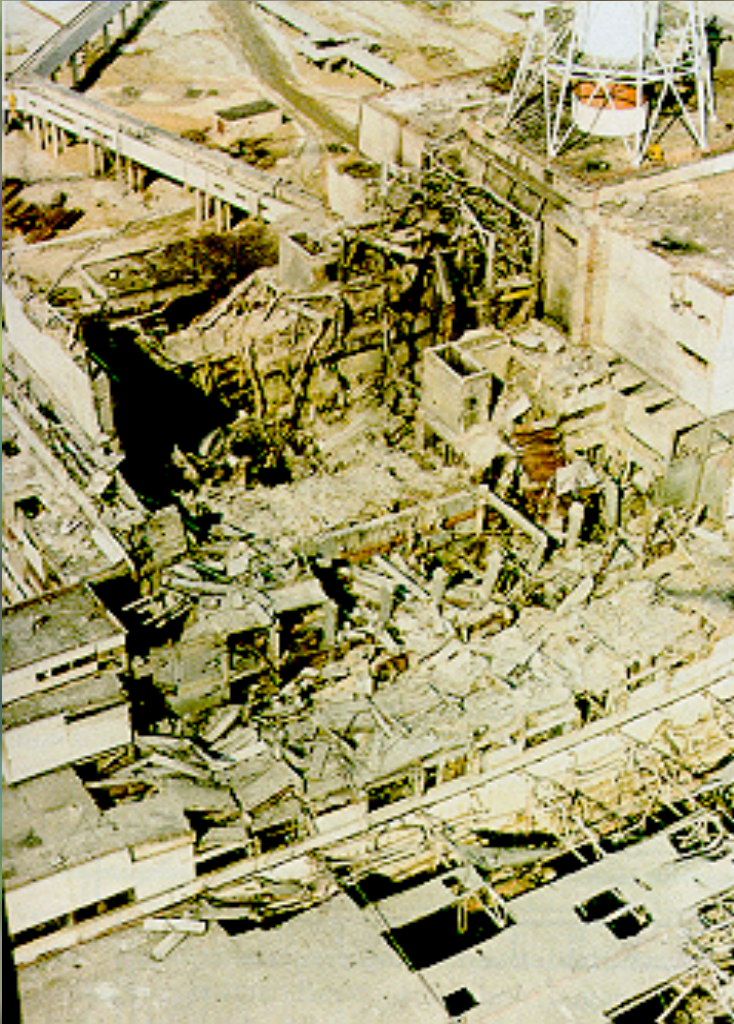
- Plants are generally thought to be safe
- However, most plants are older, and may not be maintained properly
- Accidents do happen

Three Mile Island: March 28, 1979

- Malfunction caused release of radioisotopes into environment plus intense radiation inside facility
- Wake-up call



Chernobyl: April 28, 1986



- System that provides water to core failed, causing reactor core temps to rise over 5400F melting the uranium fuel
- Fires ignited producing a cloud of radioactive particles
- 125,000 people have died
- 576,000 are pot. victims
- expected to cause 16,000 deaths in next 50yrs

The future for fission energy

- In the 60's nuclear power was heralded as the solution to our energy problems.
- However, beginning in 1975, people began to question this technology, public opposition is greater now than ever
- Since 1975, no new plants have been planned
- Fissionable material is limited
- It appears that fission plants in their current state are not going to be the solution we are looking for.

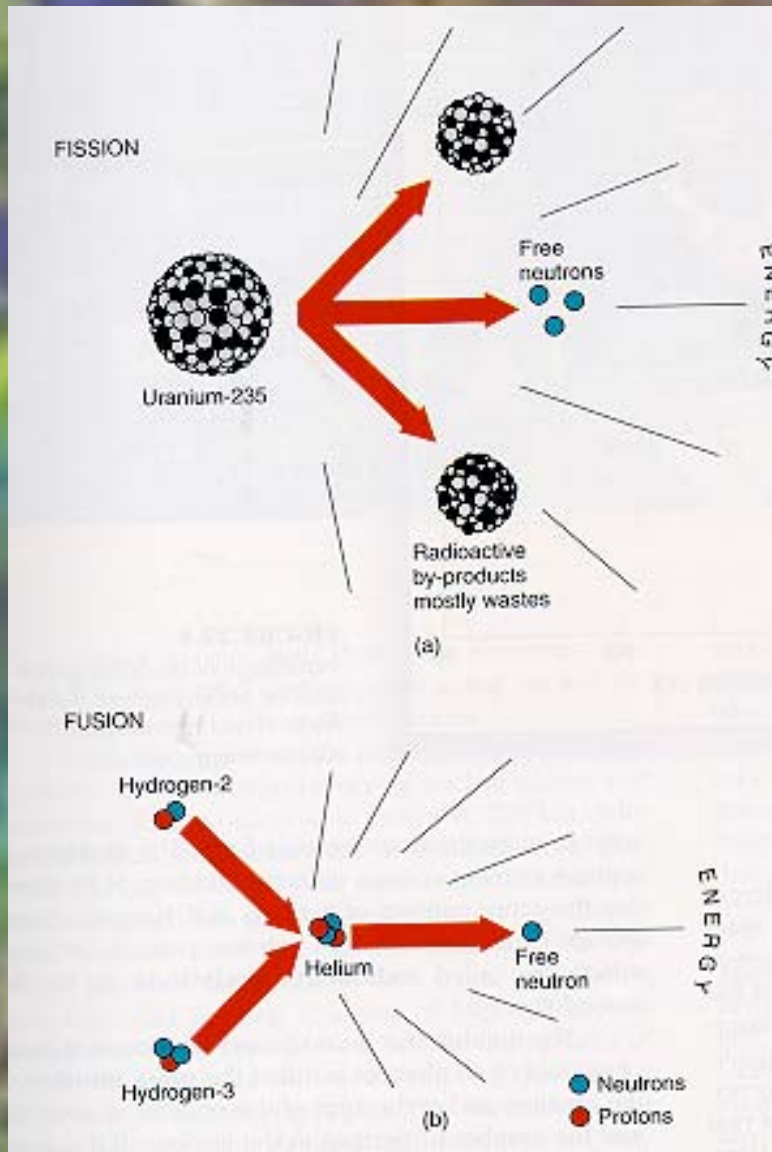
Breeder Reactors

- 99% of all uranium is U-238 which is not fissionable
- U-238 is used to absorb extra neutrons in reactors- which converts it to Pu-239.
- Pu-239 is fissionable.
- For each atom of U-235 broken down, there are 3 neutrons produced
 - one starts next reaction
 - two can convert U-238-Pu-239
 - More energy can be created than is used (breeding)
- Breeder reactors can greatly extend the lifetime of radioactive resource availability

Breeder Reactors

- However, if an accident occurs in a breeder reactor, it would be that much worse
- still have problems with disposal
- U.S. has enough Uranium right now for all reactors, so no incentive to develop breeders

What about nuclear fusion?



- Nuclear fusion -
 - combining of atomic nuclei to produce heavier atoms
 - releases a large amount of energy in the production of He from H2 and H-3
 - no waste
 - occurs in stars and bombs

Nuclear Fusion

- It requires huge amounts of heat and pressure to do (like sun)
- Fusion has been achieved, but it still requires more energy to do than is produced
- Still has problems
- Cold fusion? Great idea, didn't happen