What is Air?

Composition of the Atmosphere

We are all familiar with the major components of the atmosphere:

- Nitrogen (N_2), which comprises 78.08% of air
- Oxygen (O_2), which comprises 20.95 % of air
- Argon (Ar), which comprises 0.93% of air.

The sum of these 3 is 99.96%; the most interesting and chemically important molecules in the atmosphere represent less than 0.04% of it!

All of the other noble gases (He, Ne, Kr, Xe) are present in the atmosphere. These and the three gases given above are "well-mixed"; that is, their fractions do not vary in the lowest 100 km of the atmosphere (called the "homosphere").

The gases that we will be studying this semester are all present at much smaller abundances than those given above. In fact, those abundances are so small that they aren't discussed in percentages, but rather in mixing fraction (parts-per-million, etc.)

Some important trace gases and their approximate abundances are:

H_2O	4% to 2 ppm
CO_2	380 ppm
CH_4	1.8 ppm
O_3	10 ppb (clean troposphere) - 10 ppm (stratosphere)
NOx	2 ppb (in polluted areas)
CO	100 ppb
CFCs	100's of ppt

The units on these gases are called mixing ratios. "ppm" means parts per million, "ppb" is parts per billion, and "ppt" is parts per trillion.

A part per million is analogous to comparing the diameter of a penny to the distance between Boulder and Broomfield, or to the length of Pena Blvd (at DIA).

A part per billion is similar to what you'd get if you dissolved an Alka-Selzer tablet in an Olympic-sized swimming pool rather than a glass of water.

A part per trillion is hard to illustrate. But imagine that the entire CU campus is covered with grass and that one of those blades is blue, not green. Very rare indeed!

Knowledge of Atmospheric Composition

Our knowledge of atmospheric composition, at least for the main components, really blossomed in the late 1700's and early 1800's. Many of the minor components were not discovered until well into the 1900's.

If you are especially interested, the following links will take you to sites that have more detailed information on the composition of the atmospherie and on the history of discovery of the compounds in the atmosphere.

Antoine Lavoisier and the discovery of oxygen

The phlogiston theory

Earth's Atmosphere

ENN FULL STORY
Acid Rain Affects Large Swathes of China
August 28, 2006 — By Reuters

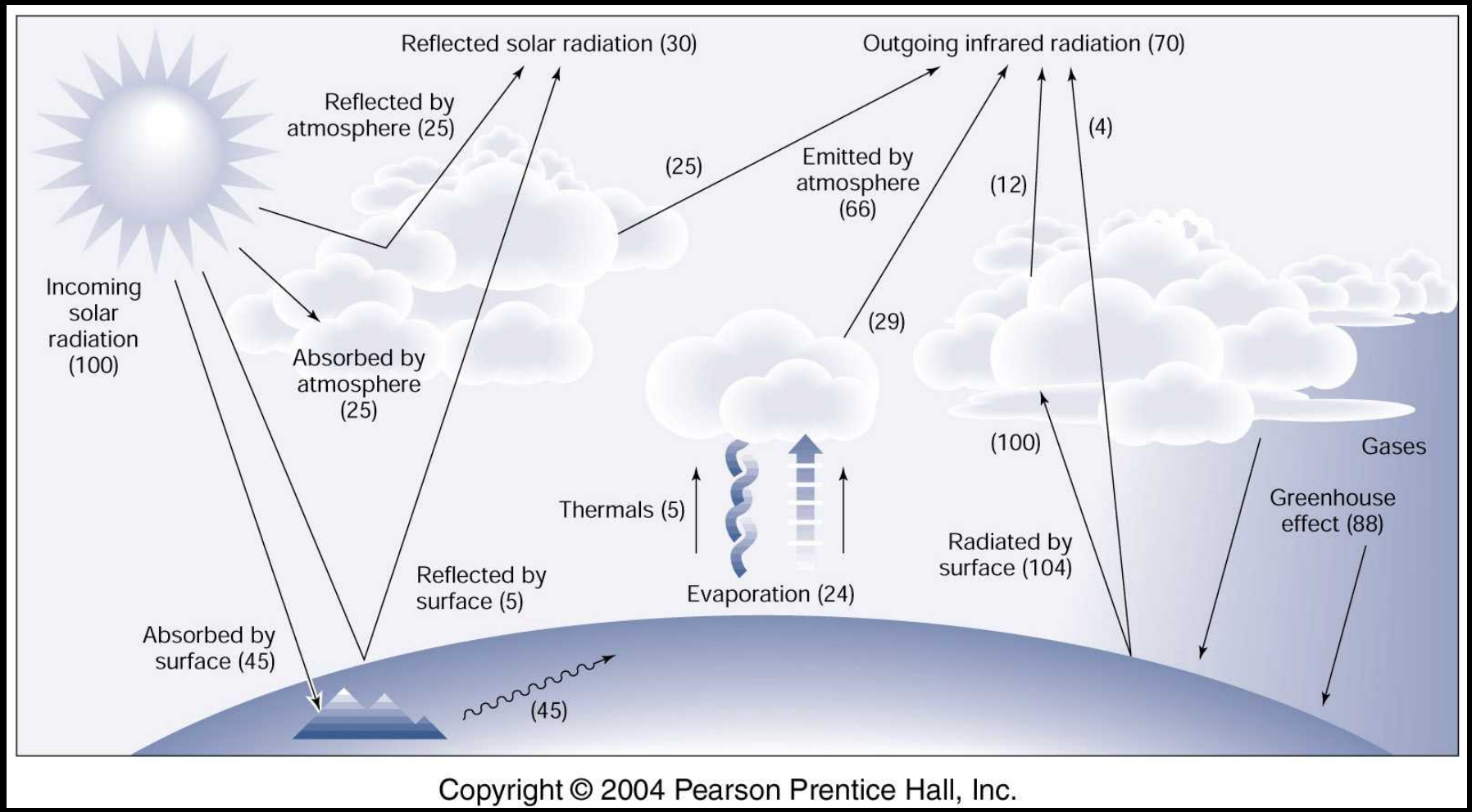
BEIJING — Acid rain caused by sulphur dioxide spewed from factories and power plants affected a third of China's vast land mass last year, posing a threat to food safety, Xinhua news agency said citing a parliamentary report. More than half of the 696 cities and counties monitored had suffered acid rain, in some cases on a daily basis, according to a pollution inspection report submitted to the standing committee of parliament, the official agency said. "Increased sulphur dioxide emissions meant that one third of China's territory was affected by acid rain, posing a major threat to soil and food safety," Xinhua cited NPC standing committee vice chairman Sheng Huaren as saying.

Discharge of sulphur dioxide in booming China rose by 27 percent between 2000 and 2005 to 25 million tonnes, making the country the world's top emitter of the pollutant. Sheng told lawmakers that China's sulphur dioxide emissions, caused largely by coal-burning power stations and coking plants, were double the acceptable environmental limit. According to the report's findings, nearly 650 out of 680 coking plants in Shanxi, the country's main coal-mining province, discharged excessive sulphur dioxide, Xinhua said.

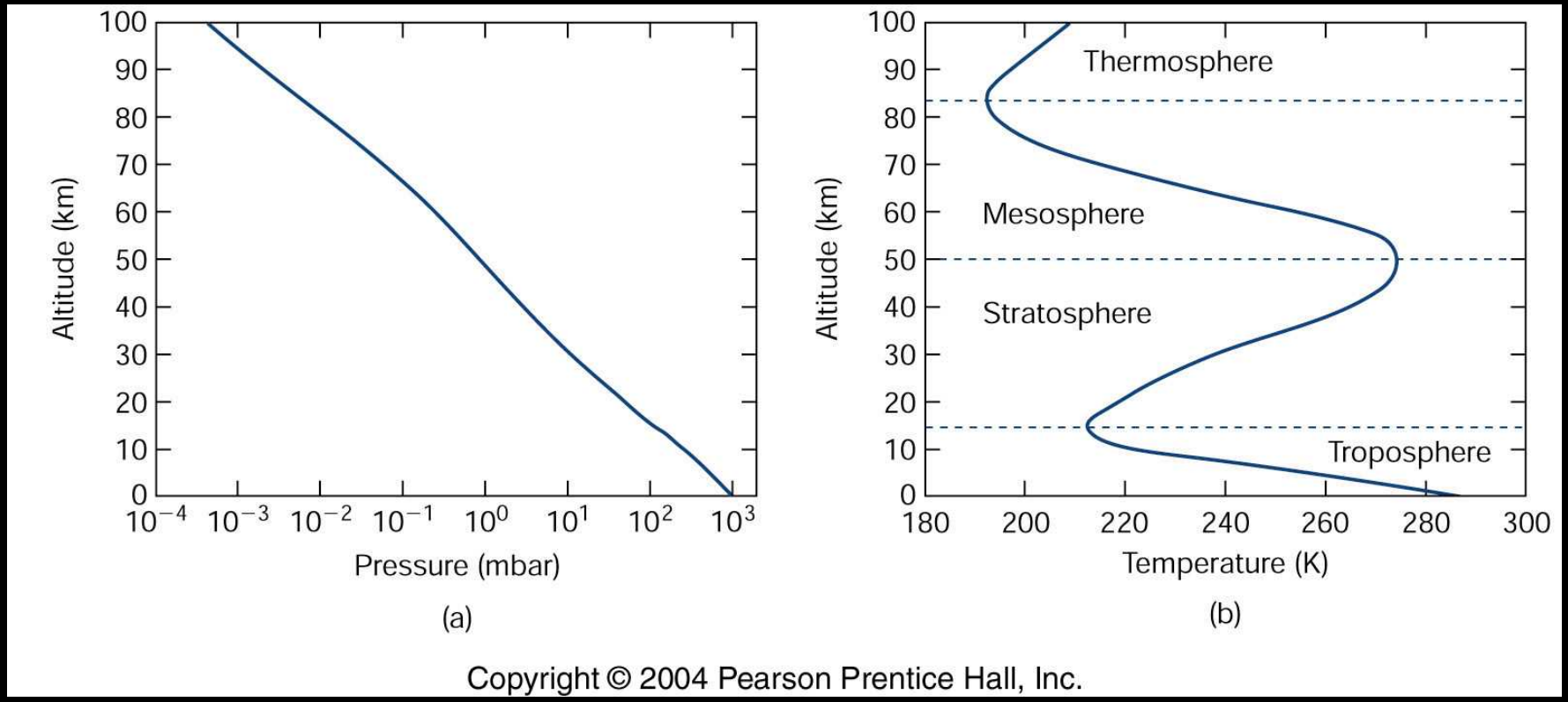
Air pollution, caused mainly by sulphur dioxide and particulate matter, was affecting some 40 percent of Chinese cities, Sheng said. China has pledged to install desulphurisation facilities in coal-burning power plants and is planning pilot emissions trading schemes to help improve air quality. The capital, Beijing, has promised to replace its notorious smog with clear skies in time for the 2008 Olympics. In the same parliamentary report, Sheng also lifted the lid on false reporting of solid waste discharge levels by local governments and companies. Actual levels of toxic chromium waste in China could be as high as five million tons instead of the 4.1 million reflected in official figures, Xinhua cited the report as saying. "Many firms report a lower figure for chromium waste for fear of being punished," Sheng said.

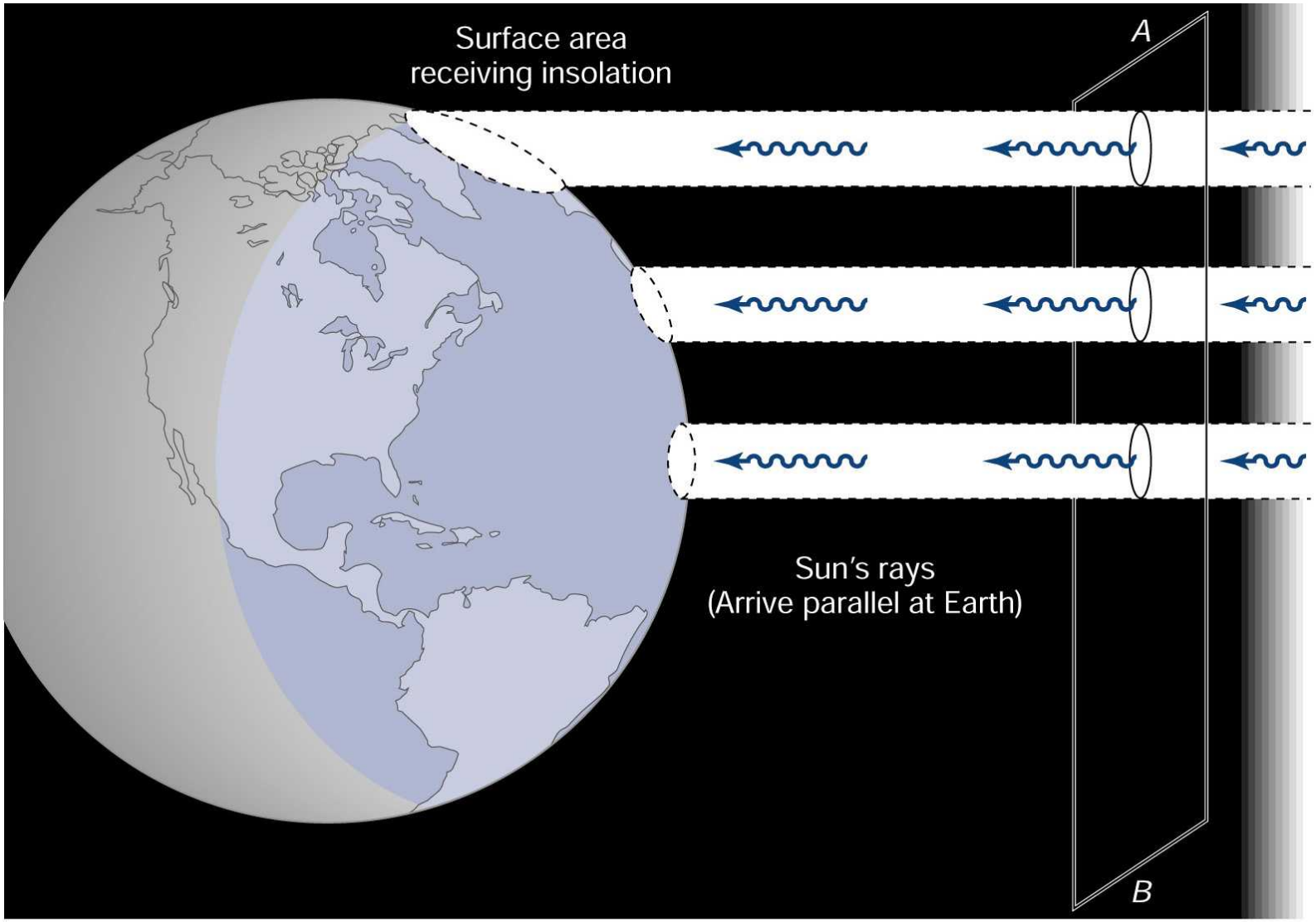
One locality had originally reported that it had 3,000 tons of chromium waste but raised the figure to 100,000 tons after learning the government would build reprocessing facilities for them instead of fining them, he said.

Global Energy Balance



How is energy distributed into the atmosphere from the surface?

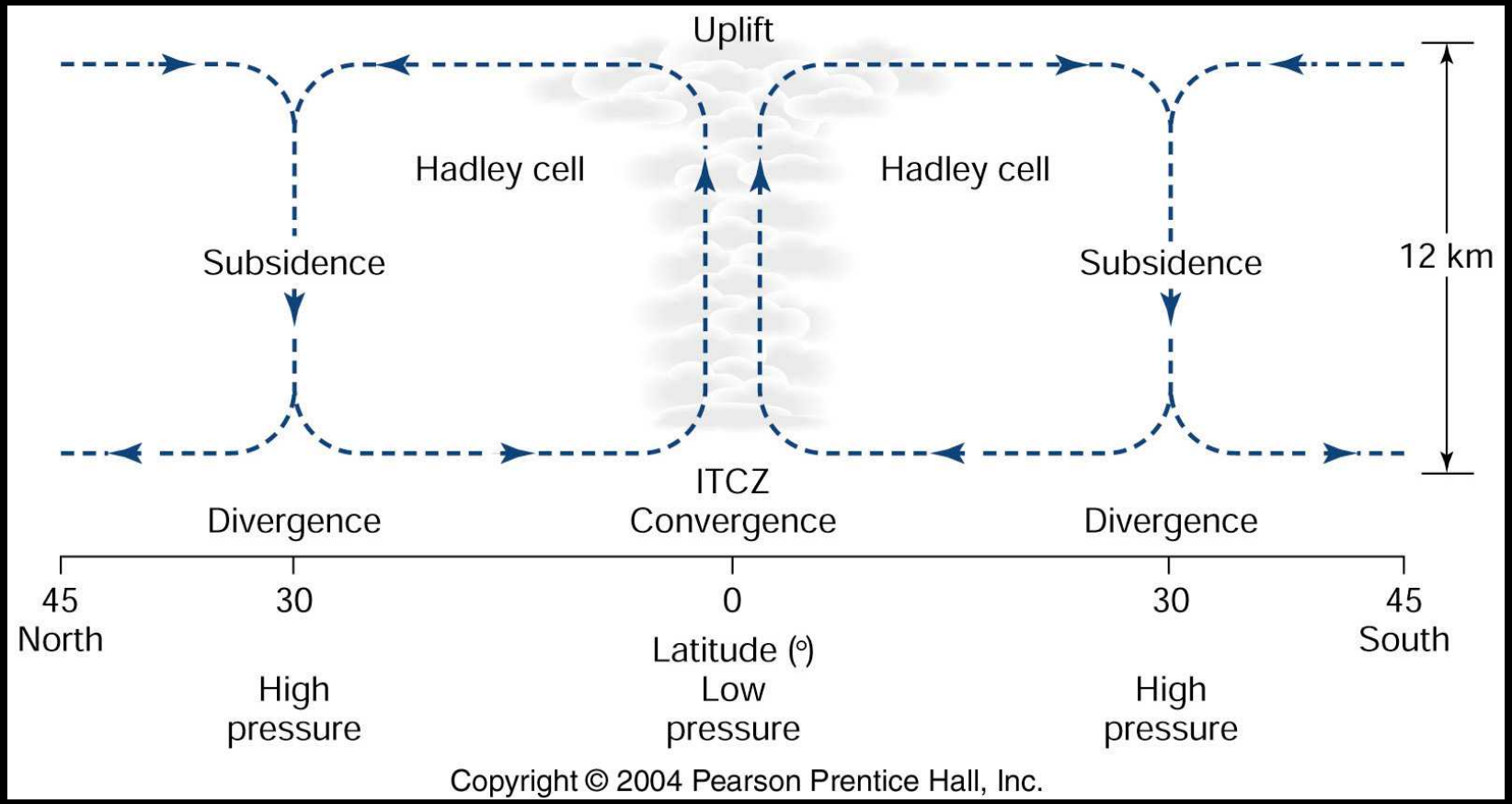




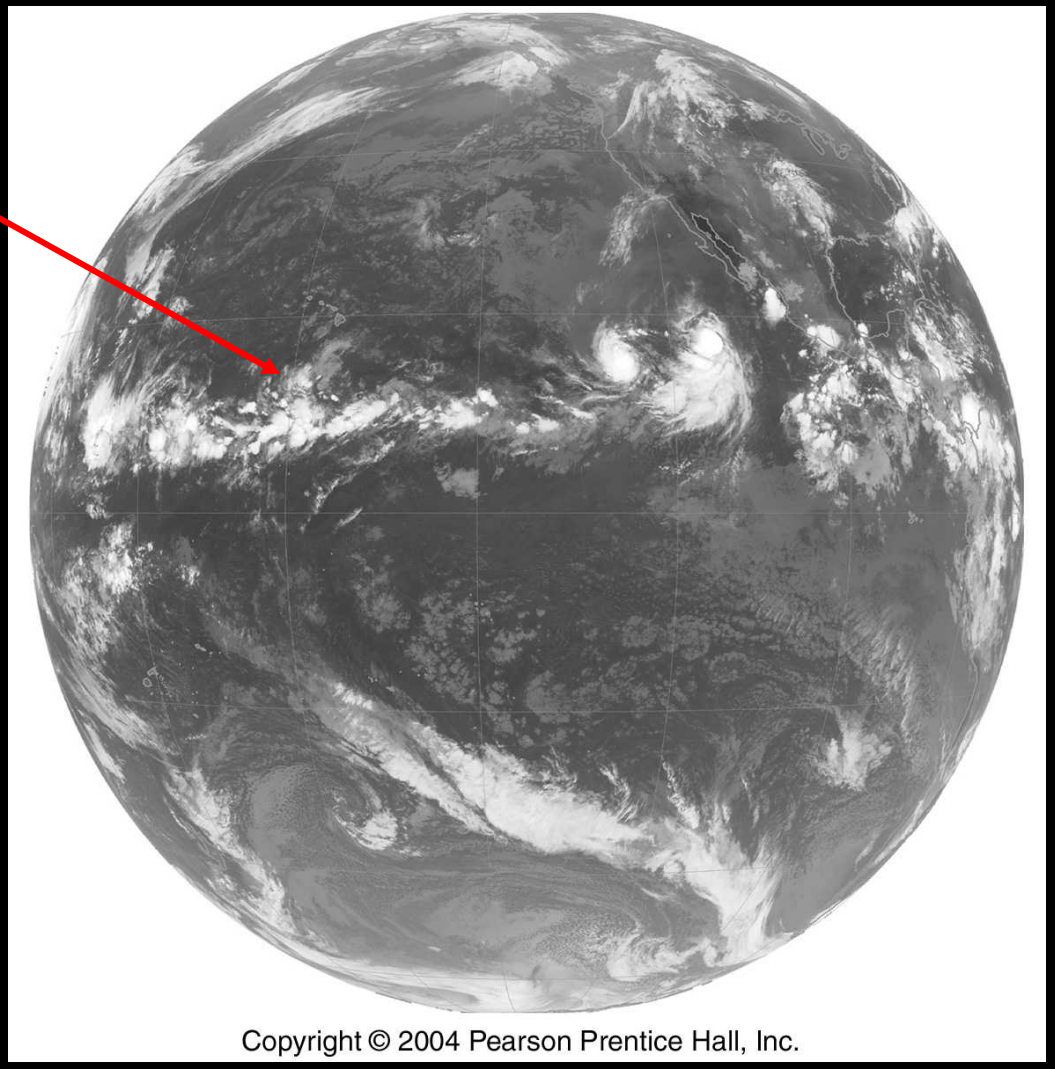
Hundreds of Chinese Villagers Suffer Lead Poisoning from Smelter
September 06, 2006 — By Audra Ang, Associated Press

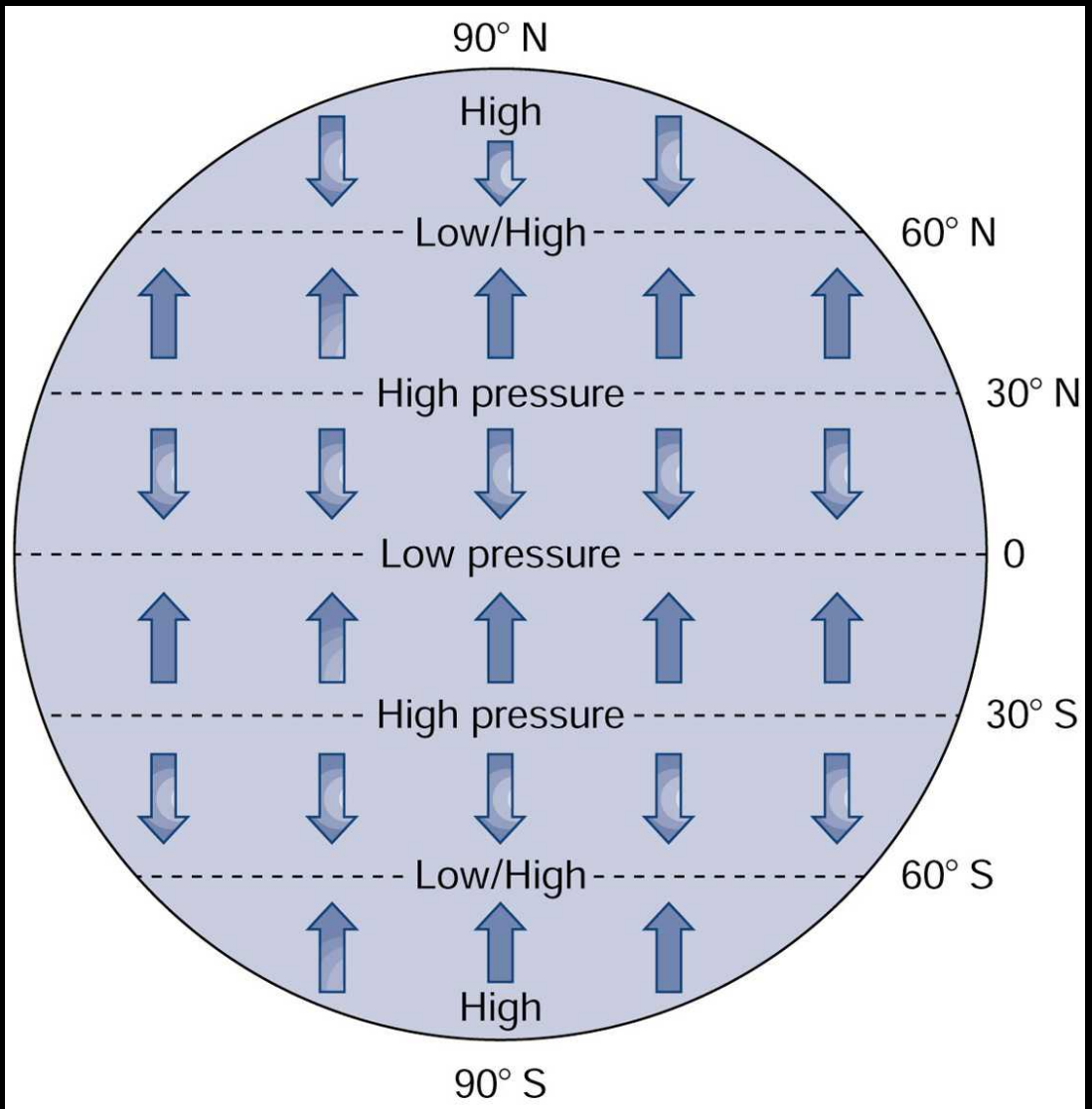
BEIJING — At least 879 people in two Chinese villages have been hospitalized with lead poisoning, probably caused by airborne waste from a nearby lead factory, state media and local officials said Wednesday. The poisonings in the poor, northwestern province of Gansu added to a string of recent pollution disasters in China that have prompted violent protests in some areas. The first sign of trouble in the villages of Xinsi and Moba came on Aug. 18, when 10 people had medical results showing high levels of lead in their blood, the Beijing Daily Messenger newspaper said. Health officials conducted checkups and "discovered that almost every family in the villages had the same kind of problem," it said. The youngest victim was five months old. "Children started feeling ill and their parents brought them to a local hospital," an official from Hui county, which oversees the two villages, said by phone. "We suspect that they were sickened by pollution caused by a lead smelter nearby that discharged waste into the air." The smelter was shut down and an investigation was under way, the official said. He refused to give his name or the name of the facility. The smelter is to be moved to another location soon and the local government was paying the hospital bills for the villagers, who were being treated at a hospital in neighboring Shaanxi province because it has better facilities, he said.

Telephones at the Xijing Hospital in Shaanxi's capital, Xi'an, were not answered Wednesday. News photos showed groups of people lining up at the hospital for check-ups, while one boy cried as a blood sample was taken from him. Excessive amounts of lead can damage the nervous and reproductive systems and cause high blood pressure and anemia. The metal accumulates in bones, and is especially harmful to pregnant women and young children. Lead poisoning can be diagnosed from a blue line around the gums and in severe cases can cause convulsions, coma and death. Environmental protection has become a prominent issue in China following a string of industrial accidents that poisoned major rivers, forcing several cities to shut down their water systems. Chinese cities are among the world's smoggiest following two decades of breakneck economic growth. The government says all of China's major rivers are dangerously polluted. Millions of people lack access to clean drinking water. Lawmakers have said they are considering raising fines for environmental violators to encourage companies to spend more on clean technology. But health problems stemming from pollution are still common and villagers in rural China are becoming increasingly frustrated. Last year, farmers in the eastern province of Zhejiang clashed with police during an anti-pollution protest at a battery factory. They said the factory discharged wastewater about 600 meters (650 yards) away from nine nearby villages, causing high levels of lead in their children's blood. At least 700 children were found to have been poisoned, state media said.

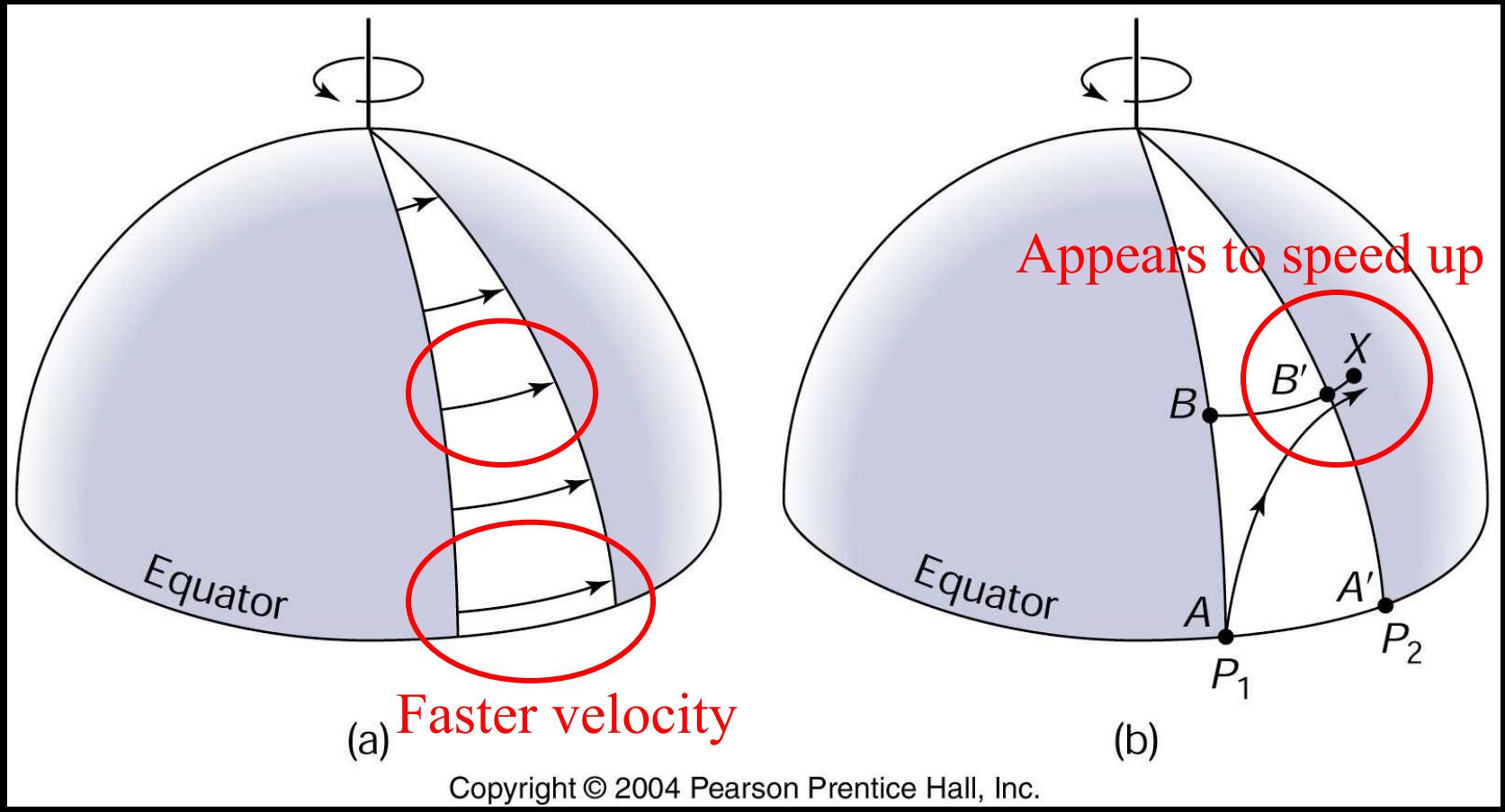


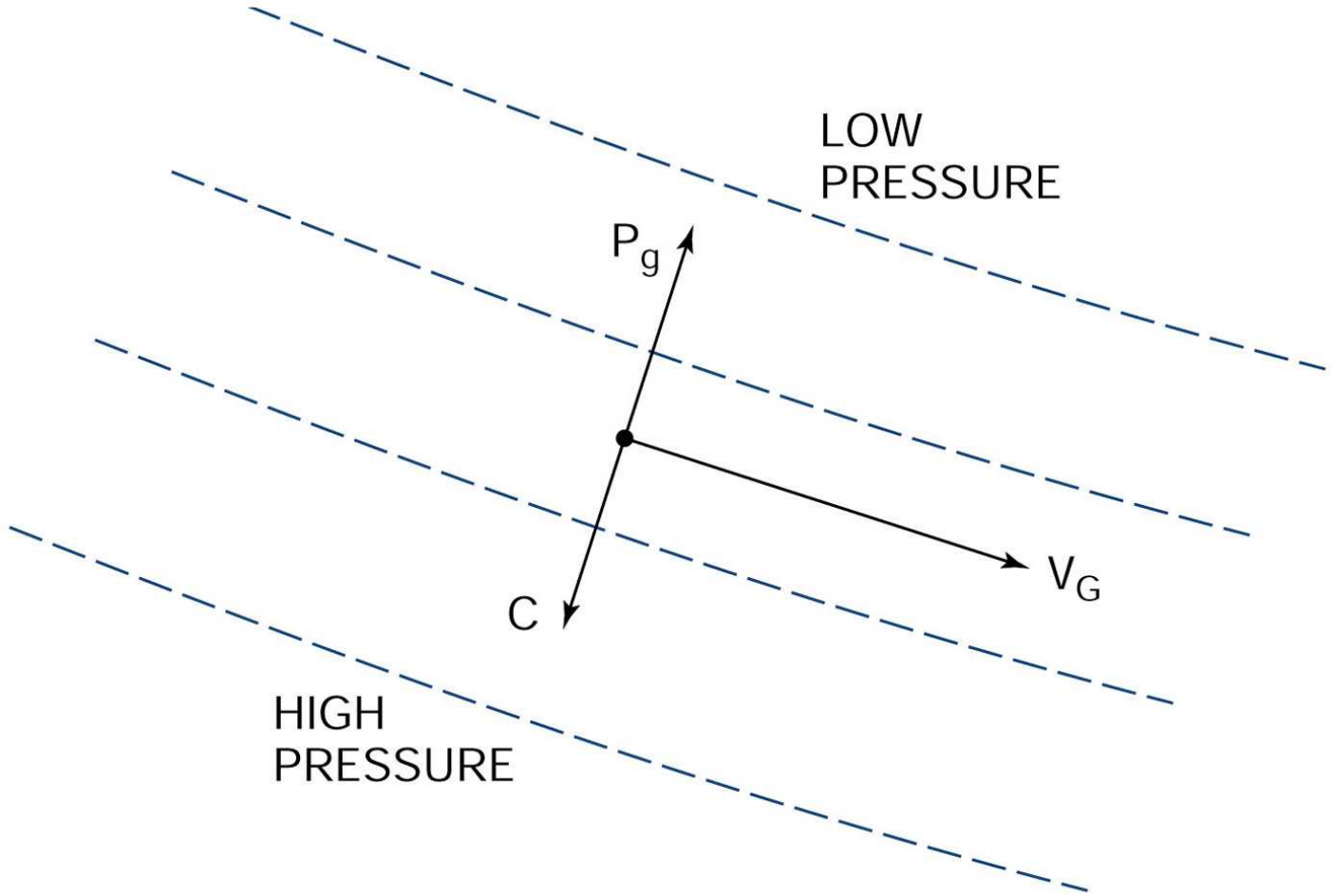
The intertropical convergence zone



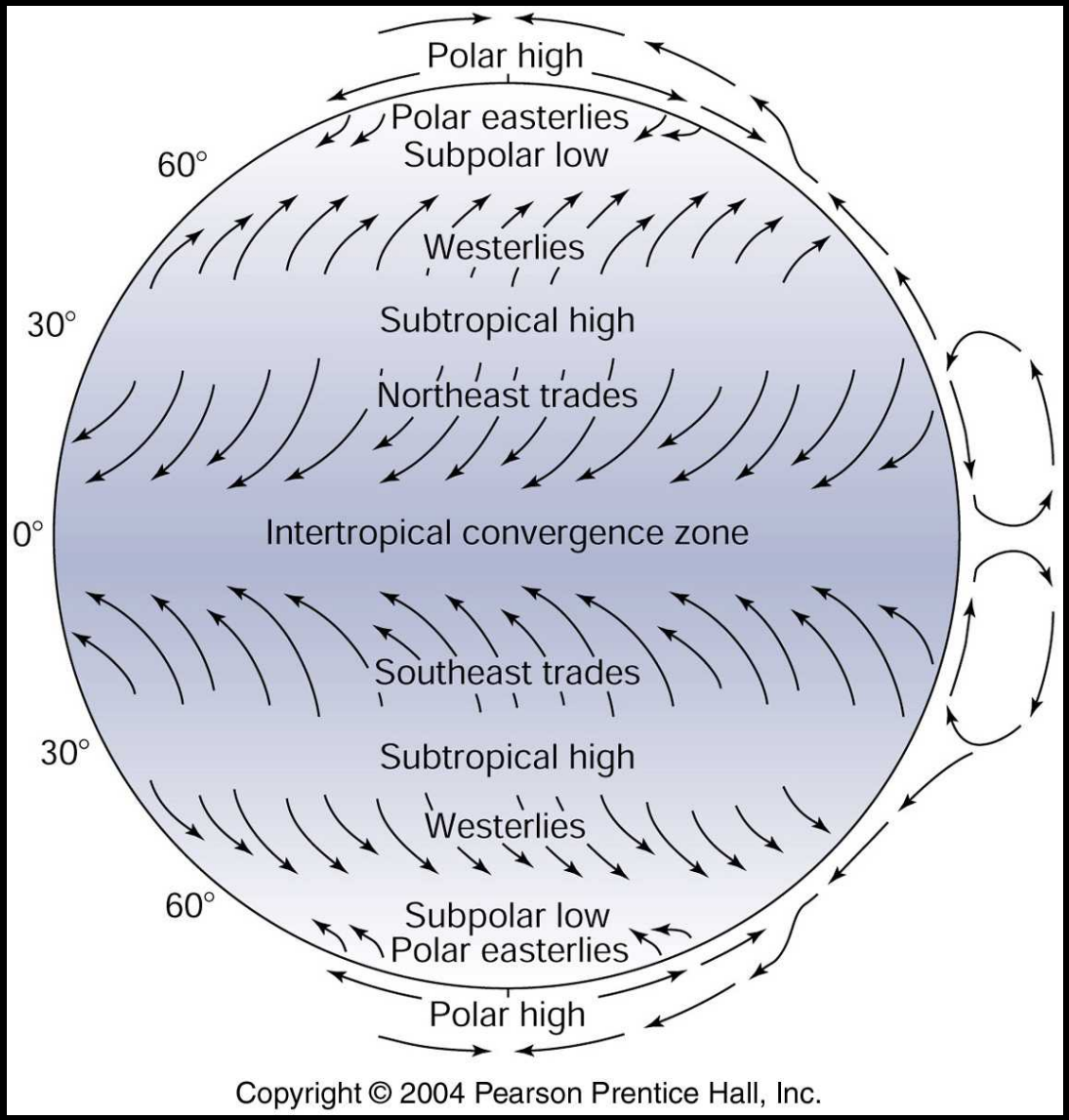


The Coriolis effect – as viewed for the northern hemisphere



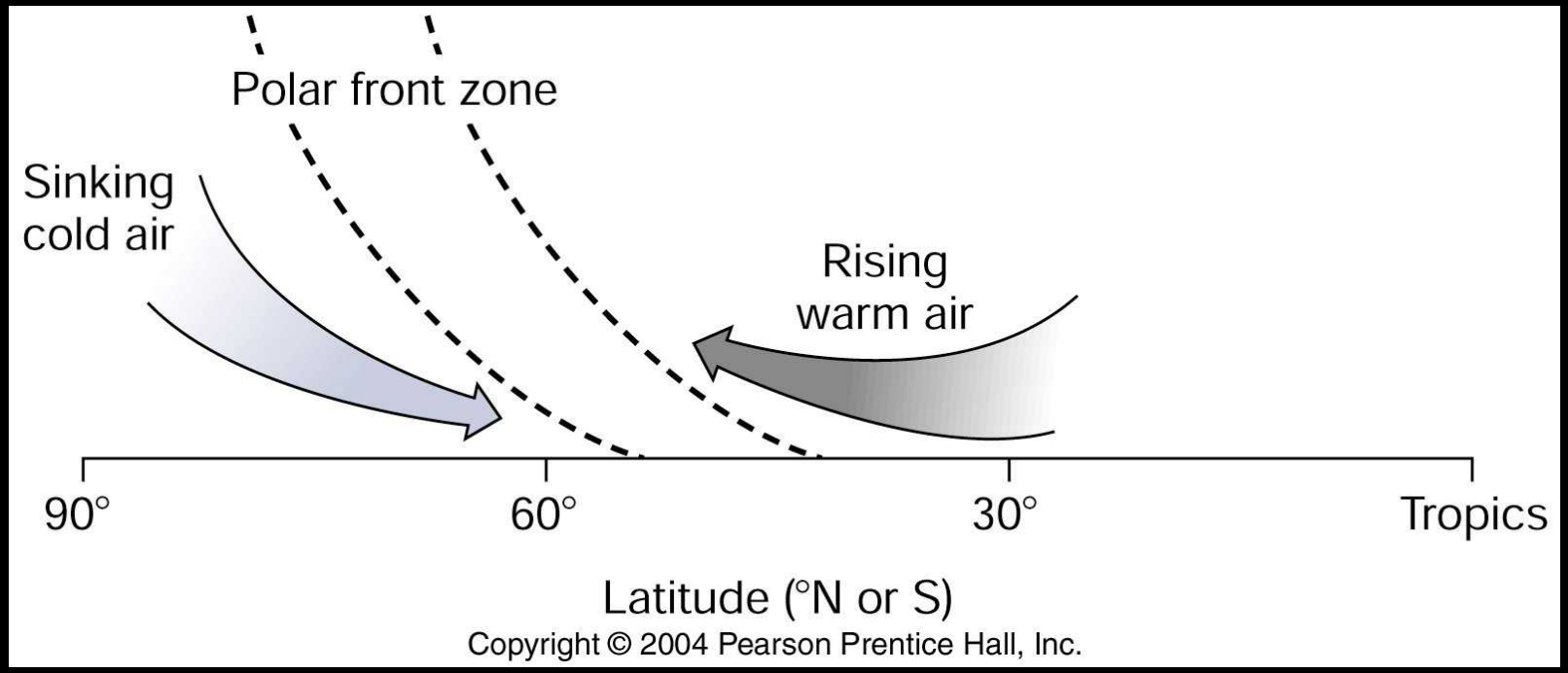


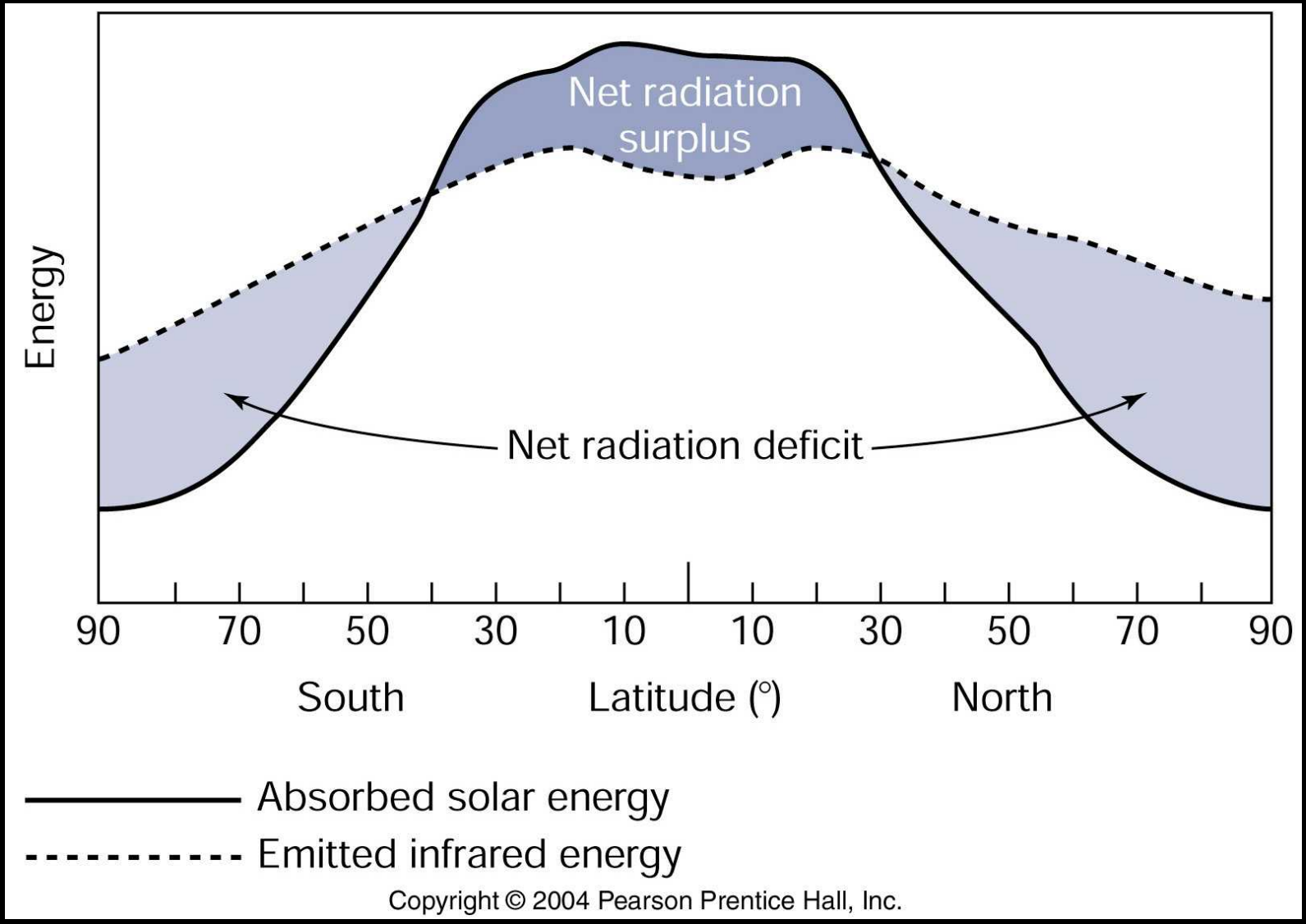
P_g = Pressure Gradient Force
C = Coriolis Force
V_G = Geostrophic Wind

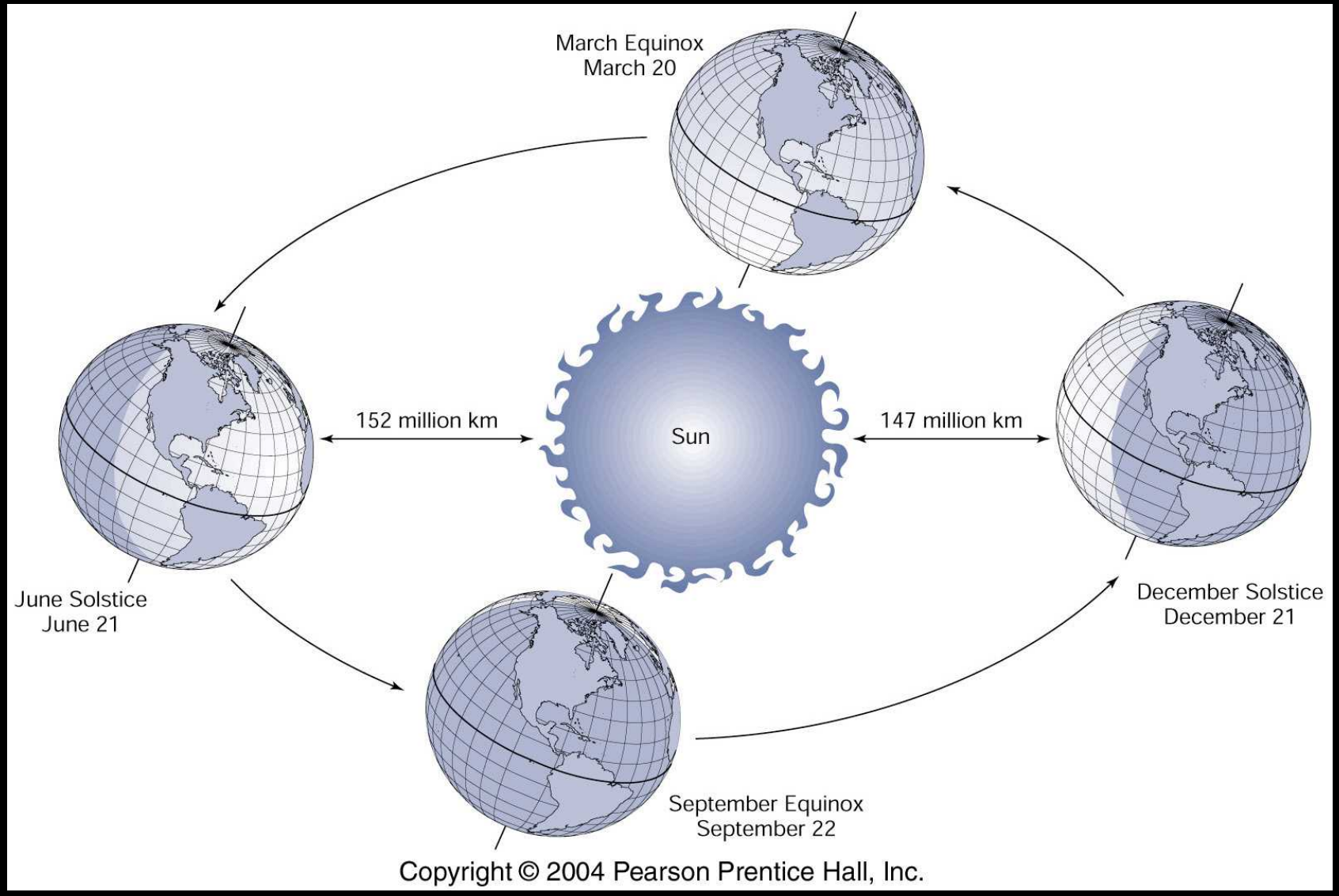


As a consequence of the Coriolis Effect (due to Earth's rotation), air does not travel in a N/S direction, but is turned in an E/W direction – giving rise to gradients that separate warm and cold air masses

“Fronts” (cold or warm)







ITCZ shifts with season – rainy weather shifts between the hemispheres

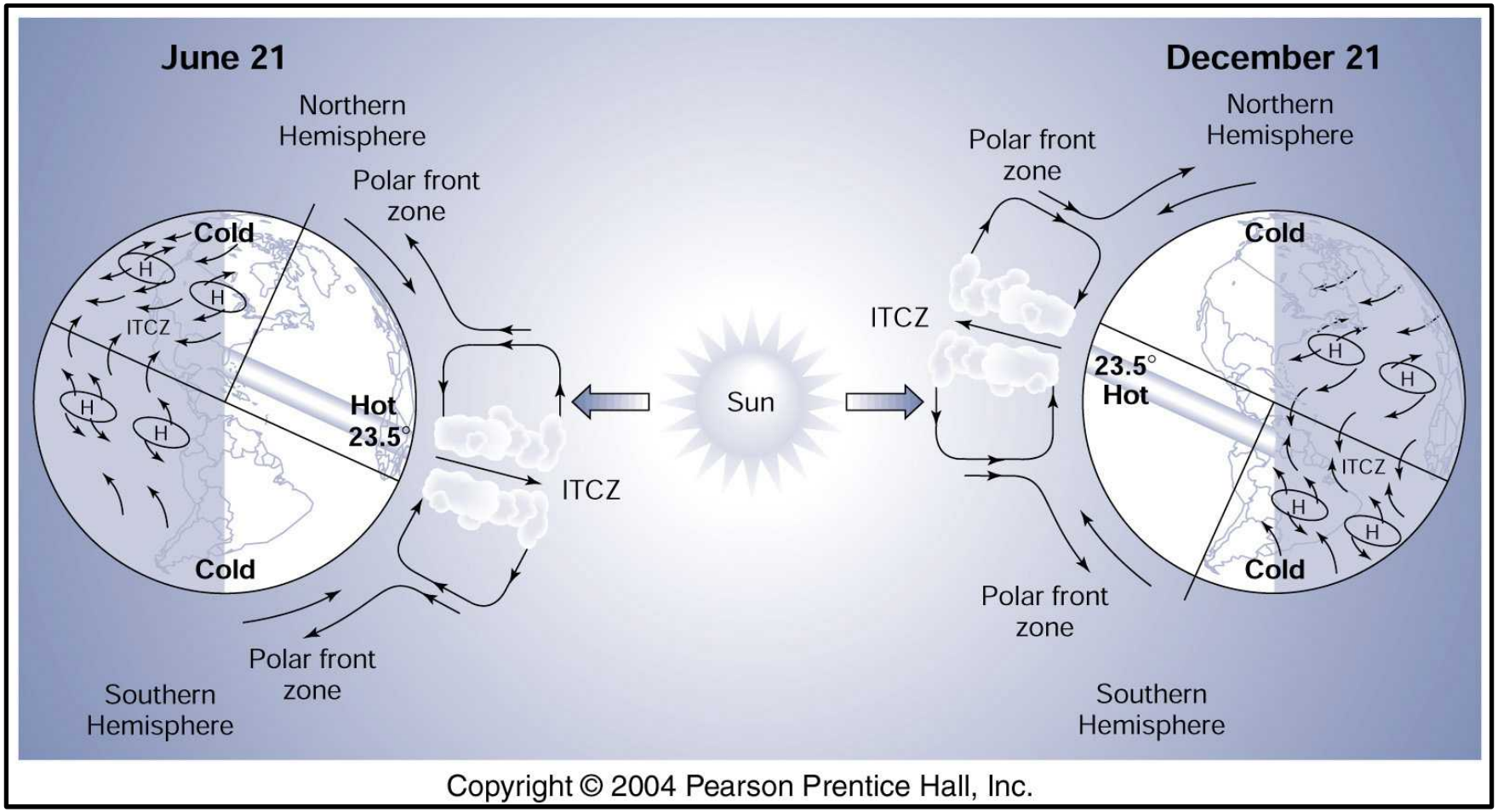
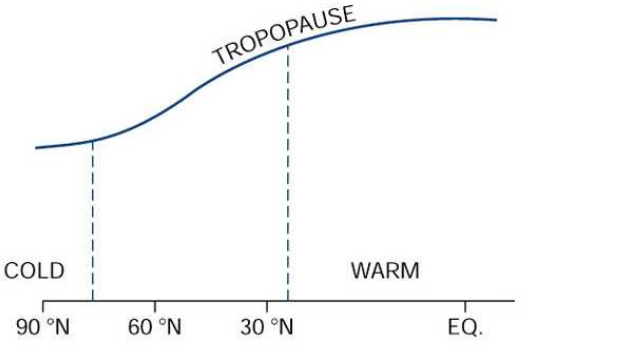
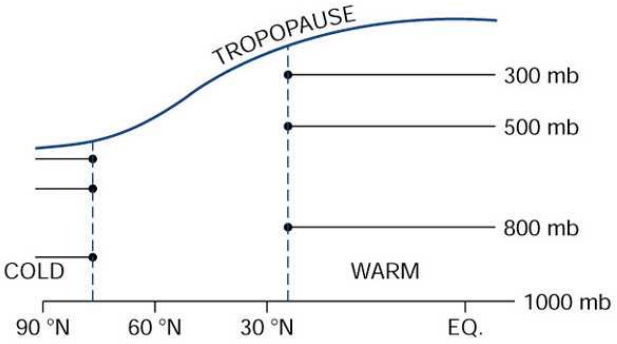


Fig. 4.16



(a)



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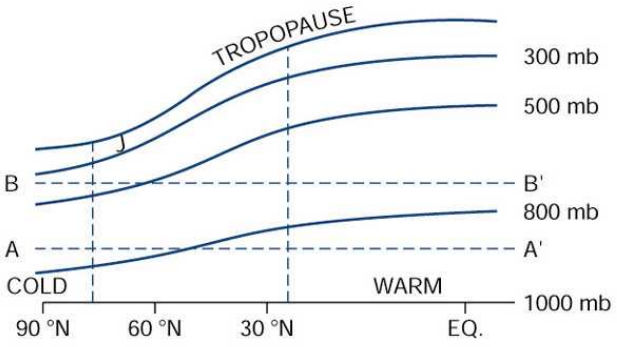

(c)

300 mb geopotential heights (the physical height at which the pressure is equal to 300 mb)