In the compression-refrigeration loop (air conditioning), which is likely to be warmer?

1. Condenser coil
2. Evaporator coil

Answer: (1) Condenser coil

See the **video**.

On hot days, a cooling tower cools ________.

1. Water from the condenser
2. Refrigerant as it moves through the compressor
3. Coolant from the evaporator

Answer: (1) Water from the condenser

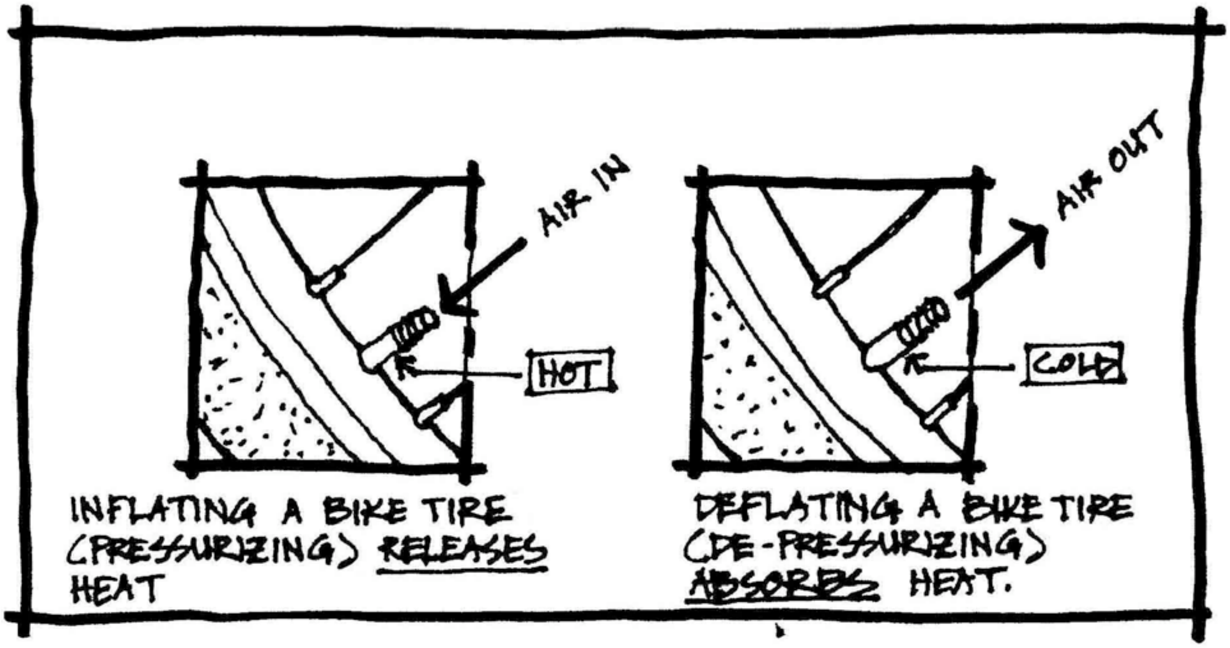
See the **video**.

The cooling tower water loop removes heat from the condenser side of the chiller and deposits it into the air.

Pumps move the water to the cooling tower, where it cascades over baffles and is cooled by exterior air. When needed, an impeller fan on top of the cooling tower draws air over the splashing water, boosting the rate of heat transfer. Importantly, the water in the cooling tower does not directly mix with the refrigerant (or coolant) in the chiller, but rather only transfers energy through a heat exchanger.

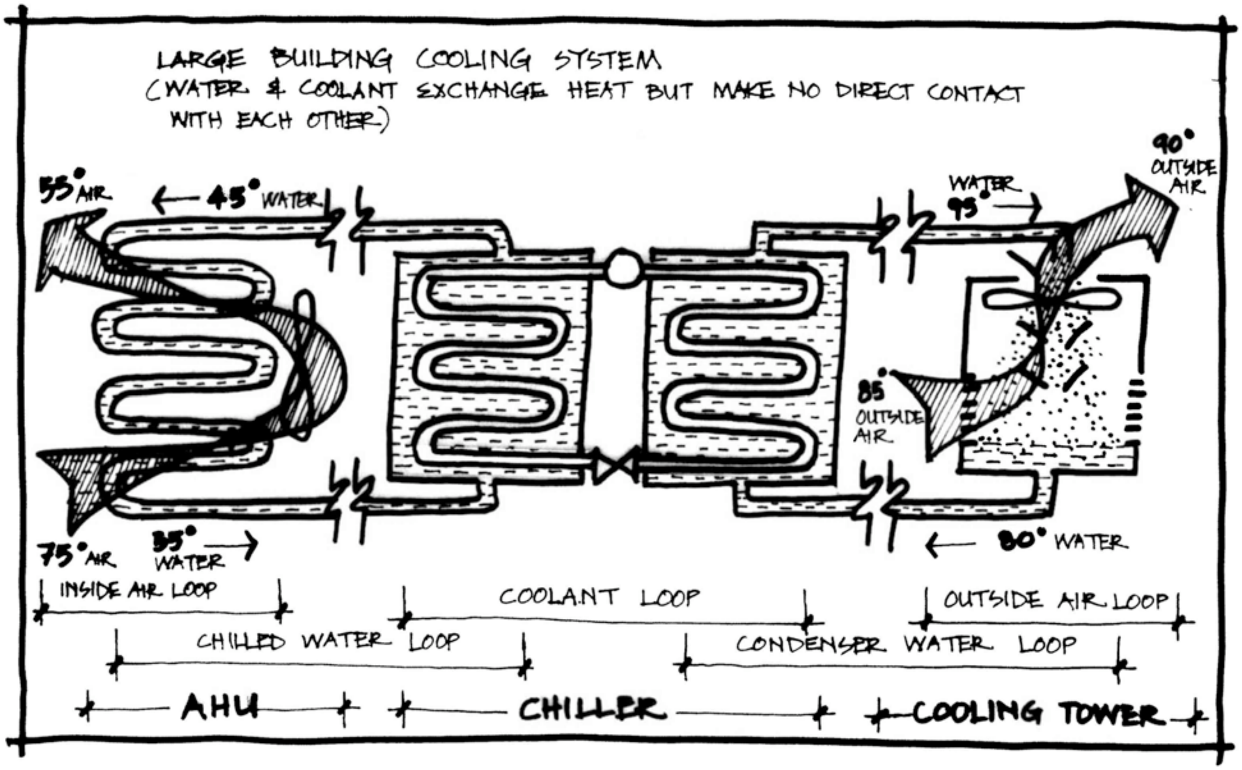
Unlike mechanical heating—which we see in our everyday lives when air, fuel, and a spark combine to create combustion and heat—mechanical cooling is less intuitive. There are two nonobvious rules of physics one must recognize in order to visualize the compression-refrigeration (air conditioning) cycle:

1. The heat of vaporization is powerful. Large quantities of heat are *consumed* to change a liquid into a gas (evaporation or boiling), and large quantities of heat are *produced* when changing a gas into a liquid (condensation). So coolant that is evaporating or boiling is cold and coolant that is condensing is warm.
2. The boiling point of a fluid is a function of pressure. Low pressure lowers the boiling point temperature and induces boiling (evaporation); high pressure raises the boiling point temperature and induces condensation. All of this boiling and condensing can be accomplished by pressurizing or depressurizing the coolant. Water boils in the high altitude (low pressure) of Denver at about 195° F and boils in a pressure cooker anywhere at about 230° F. This means that boiling can be induced by simply reducing the coolant's pressure in the evaporator, causing the evaporator coil to become cold; condensation can be induced by simply increasing the coolant's pressure in the condenser, causing the condenser to become warm.



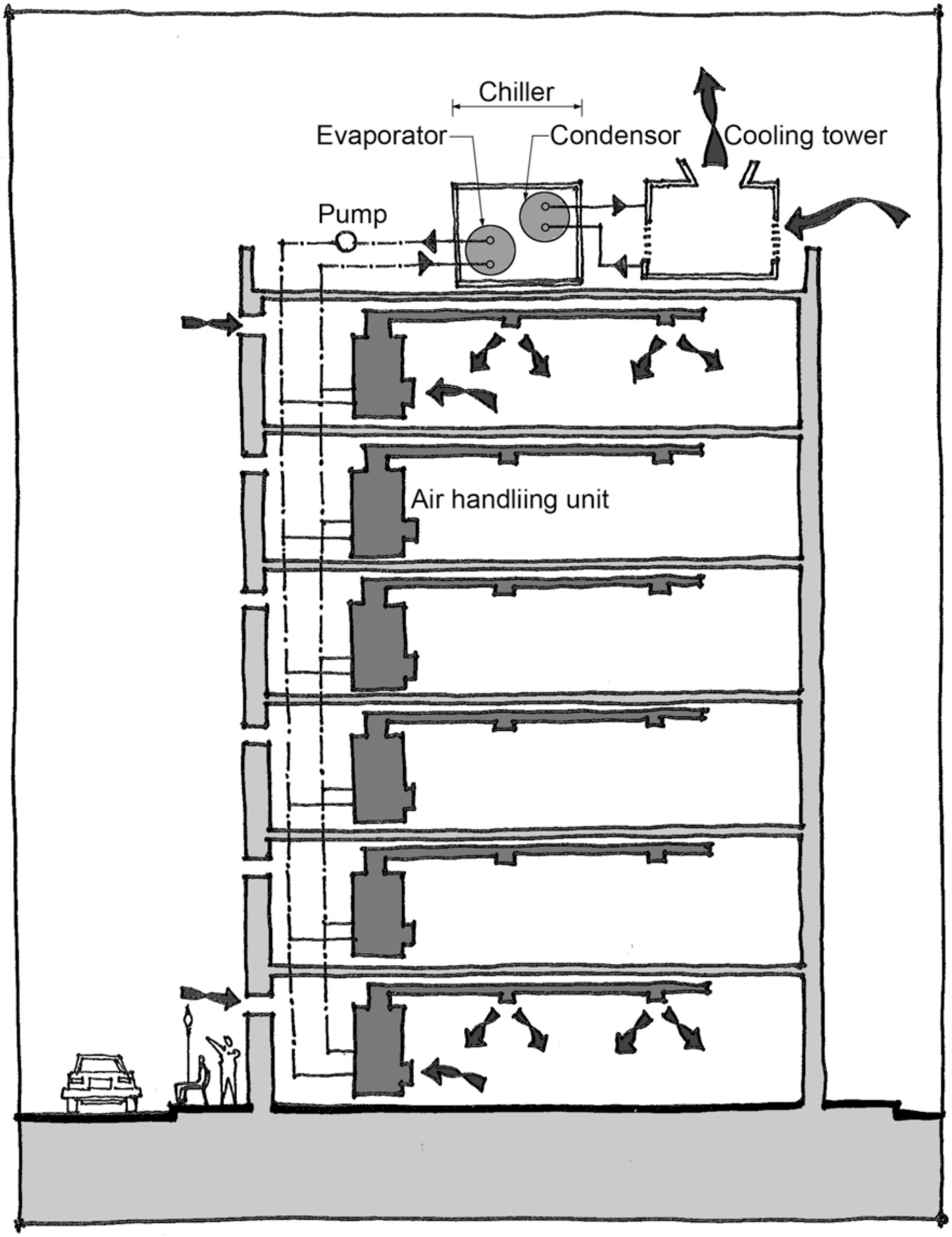
The relationship between pressure and temperature

You directly experience something like mechanical cooling when an aerosol can that has been sprayed cools in your hands. By releasing the nozzle, you release some of the pressure inside the can, and with decreasing pressure comes evaporation of the fluid. Evaporation requires heat in order to change the liquid to a gas, and your hand feels colder because the can sucks heat away from it to facilitate a state change inside the can itself.



For larger buildings, campuses, and even some neighborhoods: Pumps move water, cooled remotely in a chiller plant, for use in the cold coil of air handling units. Separate pumps move a different volume of water from the hot side of the chiller to be cooled remotely in an open loop by air passing across the baffles of the cooling tower. In this way, heat, generated by a desk lamp on a summer day, may be carried away by indoor air, to chilled water, to coolant, to condenser water, and finally to air interfacing with a district cooling tower several blocks away.

BUILDING MECHANICAL SYSTEM



Water, chilled by the (cold) evaporator side of a rooftop chiller feeds air handling units, serving each floor. Water looping through a cooling tower lowers the temperature on the hot condenser side.

A machine that uses a reversible compressive refrigeration loop, so that both coils may take the role of either evaporator or condenser, is called a __________.

1. Heat sink
2. Air handling unit (AHU)
3. Heat pump
4. None of the above

Answer: (3) Heat pump

See the **video**.