Arch 463
ECS
Fall 2017 **Name_______________________________________**

Quiz #4

"Innovation on High Ground"

South façade.

For this problem you are a teaching assistant. You're trying to understand the new RMI headquarters building so that you can prepare a lecture about it to an ECS class. The text and illustrations are from a recent online *Architecture Magazine* article <http://www.architectmagazine.com/post-occupancy-study-rockymountain-institute?utm_source=newsletter&utm_content=&utm_medium=email&utm_campaign=ABU_112117%20(1)&he=3800532aeffc75bb97271eeda04ed659237a0f93>

The Rocky Mountain Innovation Center

Basalt, CO, by ZGF Architects.

The Innovation Center in Basalt, Colo., might be a small building, but it has a big story to tell. Located near the tony resort town of Aspen, the 15,610-square-foot two-story structure opened in December 2015 as the headquarters for the Rocky Mountain Institute (RMI), the sustainable-energy nonprofit research group founded by Amory Lovins. So it's only fitting that the institute, working with Portland, OR–based ZGF Architects, designed the Innovation Center to be the highest-performing building in one of North America's coldest climate zones.

Remarkably, the project, located 6,600 feet above sea level, has no central heating or air conditioning. In winter, when nighttime temperatures regularly dip into the single digits, the building, clad in Colorado sandstone, zinc panels, and untreated juniper wood, stays warm inside largely because of its super-insulated envelope and passive solar features. In the summer, exterior venetian blinds cover the south-facing windows, controlling solar gain; at night, windows automatically open to draw in cooler air. A rooftop solar photovoltaic system generates enough electricity to meet the building's energy needs—plus enough to charge four electric vehicles.

The first design challenge for ZGF was to create a super tight building envelope. The Innovation Center's walls are rated R-50; the roof, R-67. Both were built using foam-core structural insulating panels. The juniper on the exterior was chosen for its durability and was harvested from areas in Oregon where the wood has become invasive. Windows are quad pane and include two panels of Alpen Heat Mirror glass and two film layers; the gaps between the panes are filled with krypton gas, and the thermally broken framing is manufactured by Schüco International. The infiltration rate of 0.36 air changes per hour makes the center one of the most airtight buildings the institute's blower-door consultants have ever measured.

The rest of ZGF's design revolves largely around passive strategies. The building's long and narrow profile-just 52 feet wide in most places-and southern orientation (the south façade overlooks the Roaring Fork River) allow it to be almost entirely daylighted, with supplemental illumination from overhead and desktop LED fixtures. Two interior light shelves, one on each floor's south-facing wall, help direct daylight deeper into the building and reduce glare. On the first floor, the architects gained an extra foot of ceiling height by running all the data, mechanical, and electrical systems within a cross-laminated timber (CLT) structure made of salvaged beetle-kill pine. The CLT sequesters carbon and reduces the need for concrete and steel, and the extra ceiling height helps maximize the building's daylighting and natural ventilation.

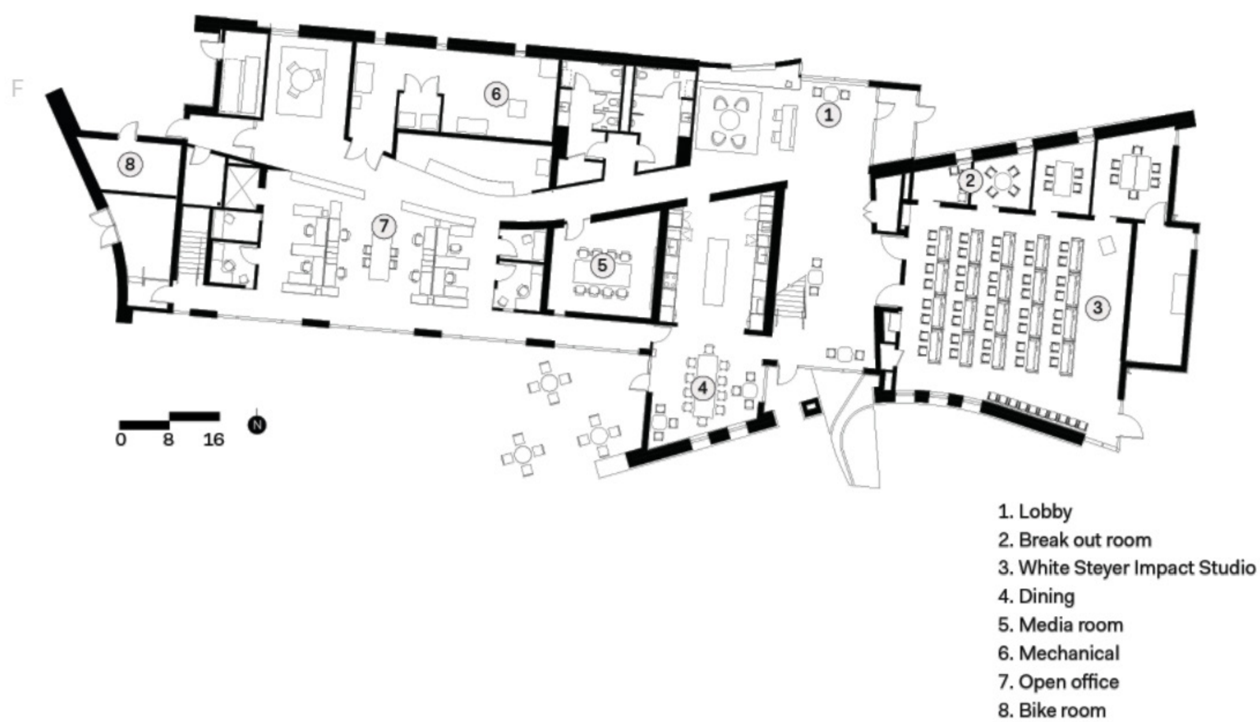
More than half of the office's southern façade is made up of windows, which help capture solar heat gain in the winter. In addition, thermal mass—in the form of the building's thick concrete floors—absorbs heat from the sun, computers, lights, and from the workers themselves, and releases it over time. In the summer, when the temperature indoors reaches 77ºF, exterior blinds lower automatically to lessen additional solar gain. Some windows also automatically open to create a cooling "chimney" effect. If the forecast calls for an especially hot day (the control system collects data from the weather station at the airport in Aspen), the building will perform an automated "night flush," opening some of the windows to cool the building before the employees arrive in the morning.

All of these factors help to maintain the range of inside air temperature that RMI established for the building: 67ºF to 82ºF. The institute had initially targeted 64 F as the low end, but that proved too ambitious in the winter. Still, the range is wider than in most office buildings, because other factors contribute to the level of personal comfort: the air speed, Colorado's low humidity, radiant surface temperatures, and how employees bundle up or shed layers depending on the season.

On the very coldest winter days, an in-floor electric resistance radiant heating system, which is strategically located under carpeted areas around workstations, helps keep employees comfortable. The open-office plan allows air to circulate without a ducting system in warmer weather—though there is a highly efficient air-to-air heat exchanger and small ventilation ducts that bring in fresh air during colder temperatures.

The building boasts a few innovative features. Hidden in the walls and ceilings is a vegetable-based phase-change material, encased in small pouches. The material liquefies on hot afternoons and absorbs excess heat, and then it solidifies at night, releasing the heat when the building is cooler. But that's pretty much it for newfangled tech. Almost all of the building's energy-saving technologies are intentionally off-the-shelf. "We wanted people to look at it and see that net-zero is totally achievable, and it's not that much more expensive to do," RMI staffer Cara Carmichael says.

— David Hill, *Architect Magazine* online



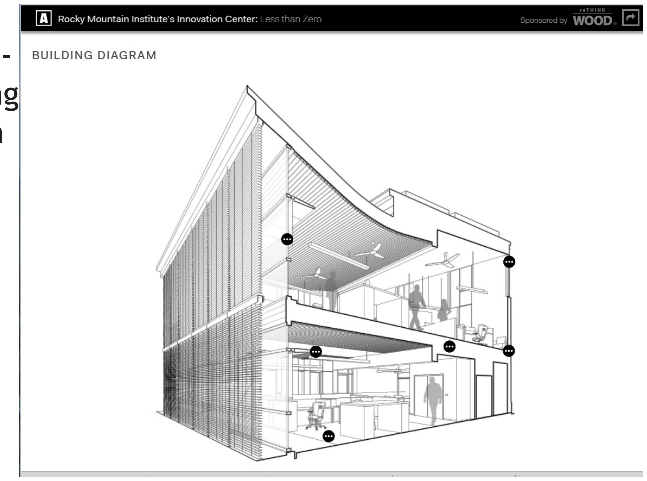
9. Office
10. Open office
11. Conference room
12. Reading room
13. Terrace

Ground floor (top) and upper floor (bottom) plans. North is up.

Photo from northeast (right).

3 pts

1. **Identify** three (3) topics (other than daylighting and solar control) that address energy-efficiency or sustainability in this building and that you think are worthy of discussion in class and **explain** why.



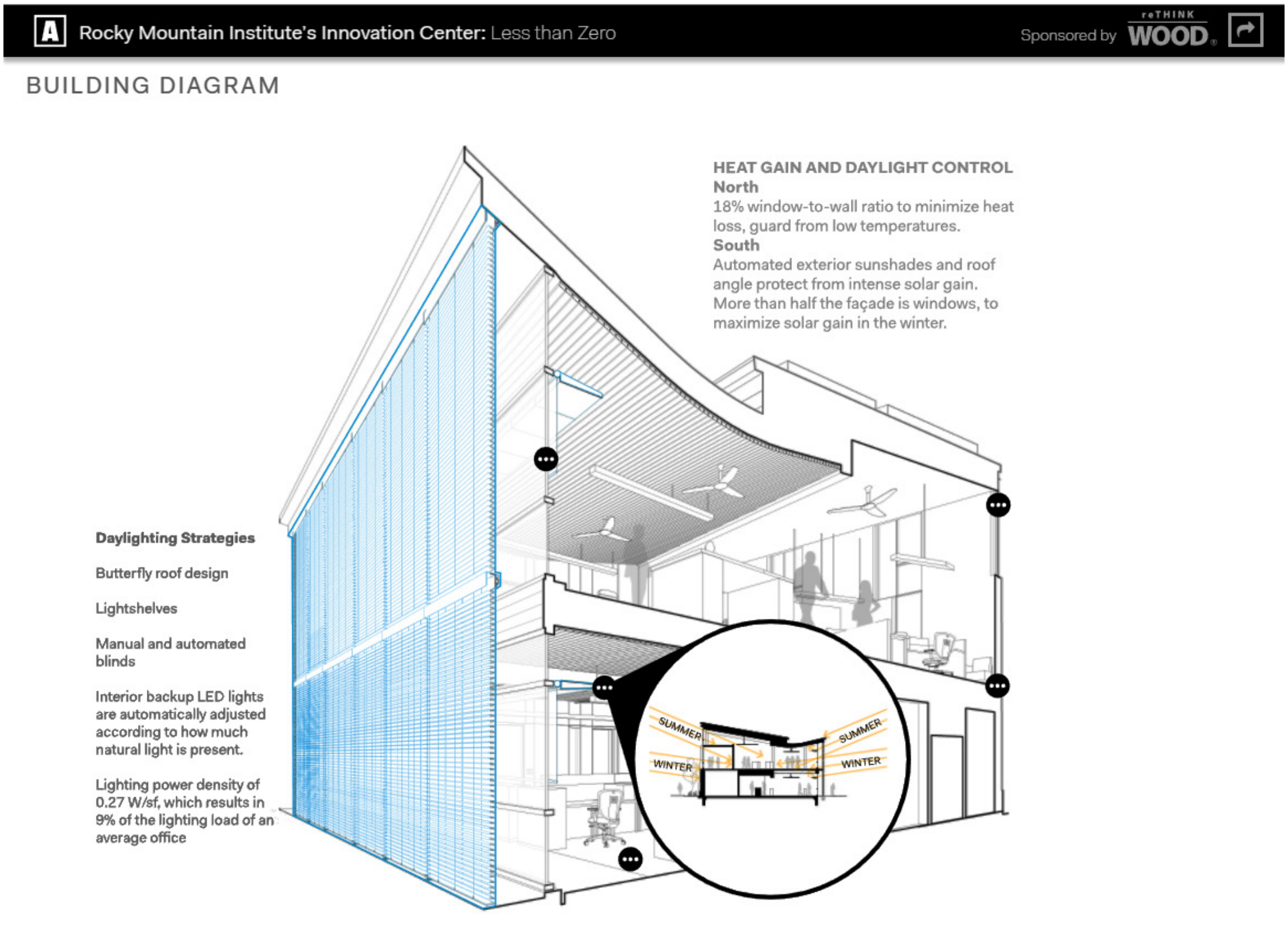
1.

2.

3.

3 pts

2. **Critique** the daylighting and solar control scheme. **Cite** and **explain** three (3) things related to daylighting and sun control that are successfully or unsucessfully employed in the original design and construction of the Innovation Center.



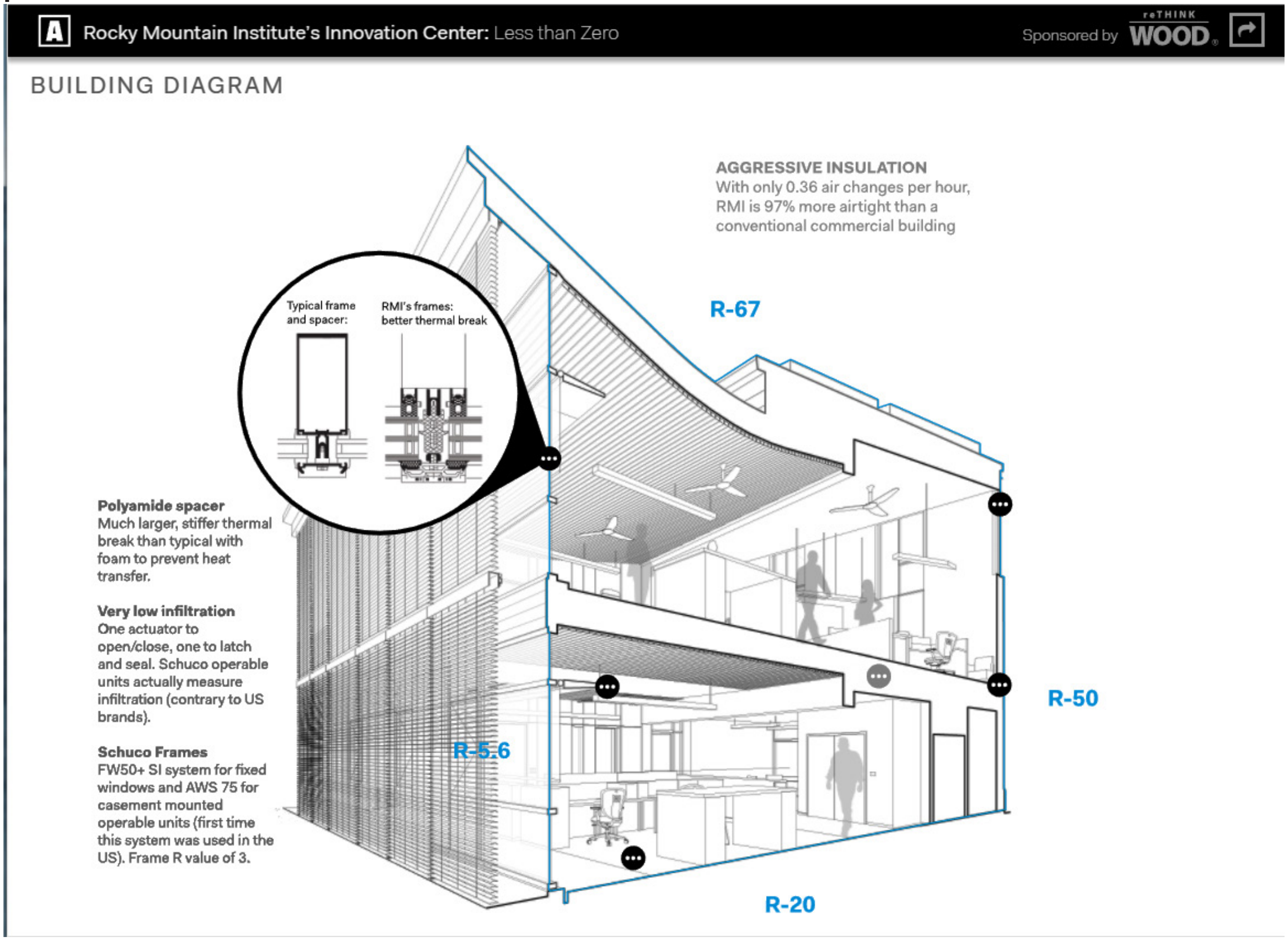
1.

2.

3.

2 pts

3. **Explain** how the south-facing glass wall in the open office plan could be improved for a higher insulation value and better daylighting and solar control. **Illustrate and explain** how it would work in the section below.



2 pts

4. **Make a case** for using displacement ventilation instead of the electric resistance radiant floor. **Illustrate and explain** how it would work in the section below.