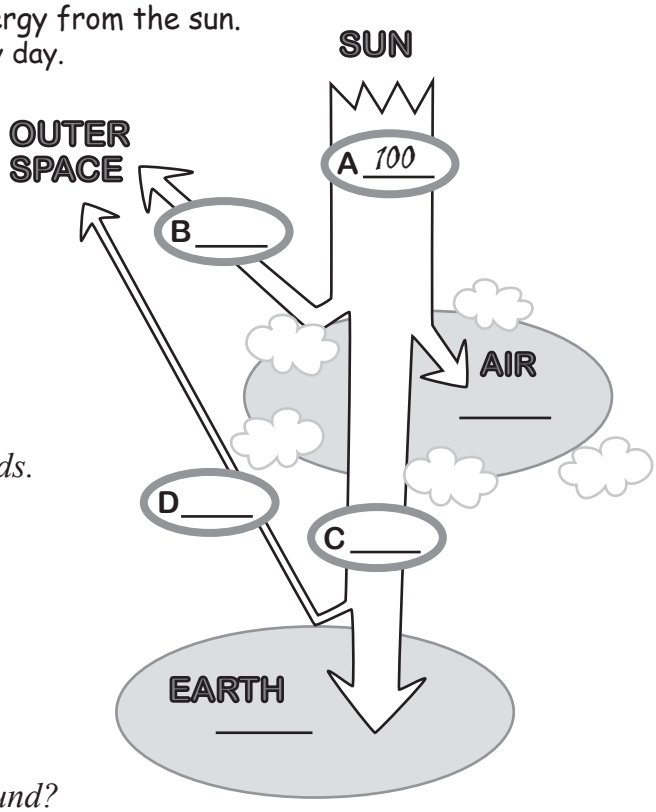
Name _____

Earth's Energy Budget: Part 1 - Sunlight

A parcel is exactly one percent of the total energy from the sun.
The sun sends 100 parcels toward the earth every day.
That's Arrow A on the diagram,
and it already has 100 written on it.



1. . The sunlight hits the clouds and air.
About one fourth of it (23 parcels)
bounce off the clouds and dust in the air
and go back out to outer space.
IMPORTANT: That is an average
for the whole world. Obviously,
some places are cloudier than others.

Arrow B represents reflection from clouds.
Write 23 on the line for that arrow.

2. More than half of the sunlight
(55 parcels) goes right through the air
and on down to the earth surface.
That's good; otherwise the earth
where we live would be dark and cold!

What arrow on the diagram
represents sunlight that reaches the ground?
Circle A B C D Write 55 on that line.

3. That leaves 22 parcels (100-23-55). That energy stays in the air. It makes the air warmer.

Write +22 on the line inside the air symbol on the diagram.

4. Some sunlight just bounces off the surface of the earth and goes back out to outer space.
That is called reflection, and it is not the same in every place. For example, more energy
is reflected from white snow than from dark soil or dark-green trees. Measurements
from satellites tell us that the average for the whole world is about 7 parcels.

What arrow represents reflection from the earth surface? Circle A B C D
Write 7 on the line next to that arrow.

Note: Dark soil and water reflect less sunlight than white clouds do. The arrow for
reflection from the earth is therefore thinner than the one for reflection from clouds.

5. The rest of the incoming sun energy (after all this reflection) goes into the ground.
Subtract 7 (for reflection) from the 55 parcels that came from the sun to the ground.

What do you have left? ____ Write that number on the line inside the earth symbol.

This is the energy that heats the earth surface (the ground and the water in oceans and lakes).
Some of it also makes plants grow. That's a very small amount, but it is important for us!

Earth's Energy Budget: Part 2 - Land and Water

6. Now, let's look at the earth surface. Remember (from Part 1) the earth surface got 48 parcels of energy from the sun.

Write a 48 on line E.

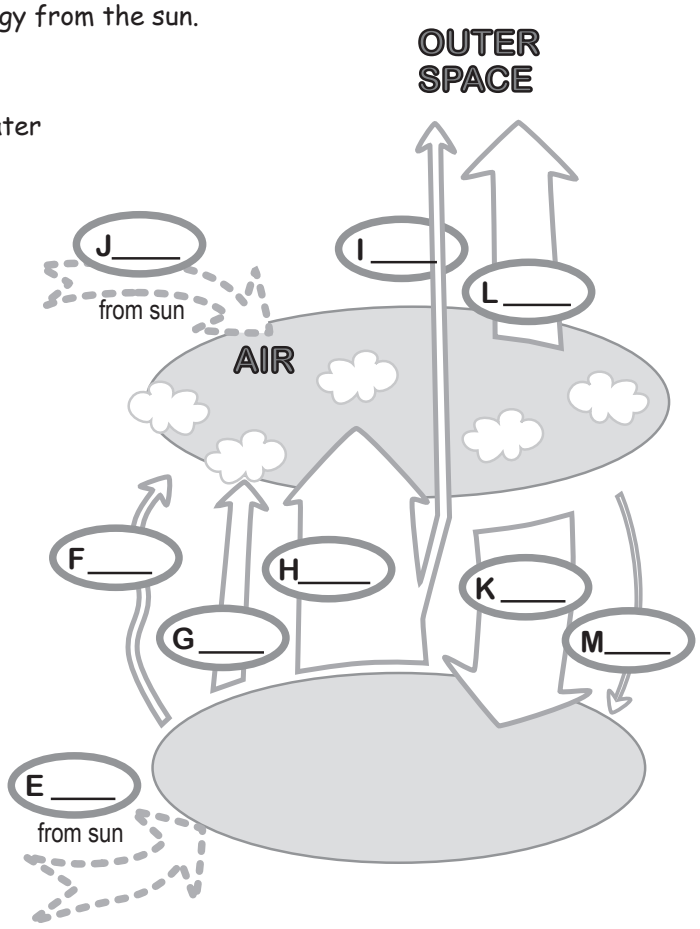
7. About 25 parcels are used to evaporate water from oceans, lakes, soil, trees, grass, and even from your skin when you sweat. This energy then moves up into the air, where it eventually becomes clouds.

Write a 25 on arrow G to represent energy moving in evaporated water.

8. 6 parcels heat the air near the ground. It's a small number, but it's important. Some of that air moves upward (because hot air rises). Some goes sideways, to make wind.

What arrow represents the energy that heats air and makes it move ?
Circle: F H K M
Write a 6 on that arrow.

9. The rest of the energy can't just stay in the earth. Every object that has heat must radiate some of it away. The earth radiates 117 parcels. About 105 of those are absorbed by the air or clouds. The other 12 go through the air to outer space.



What arrow on the diagram represents radiation from the earth to the air?
Circle: F G H K M *Write a 105 on the line for that arrow.*

What arrow represents radiation from earth to outer space? Circle: H I J K L
Write a 12 on that arrow.

Questions 6-9 were about all the ways the earth sends energy away from its surface. If you add these numbers, you might see a problem. Every day, the surface gets 48 parcels from the sun, but it "sends away" a total of 148 parcels (25 by evaporation, 6 to heat air, and 117 by radiation). In short, it sends away 100 parcels more than it gets from the sun.

The atmosphere is the solution to the puzzle. If there were no atmosphere, the energy budget would be easy to calculate. The earth's surface would be colder. As a result, it would not have to radiate so much energy away. It would also not use any energy to evaporate water or heat air.

Unfortunately, a cold, waterless, airless planet would not have any life. You wouldn't be here!

In Part 3, you will analyze the atmosphere part of the sun-earth-atmosphere system. That is the part that makes life possible on earth. Unfortunately, it is also the part that humans are altering, causing climate change.

Name _____

Earth's Energy Budget: Part 3 - The Atmosphere

10. Now, let's look at the atmosphere. Remember (from Part 1) the atmosphere gets 22 parcels of energy from the sun.

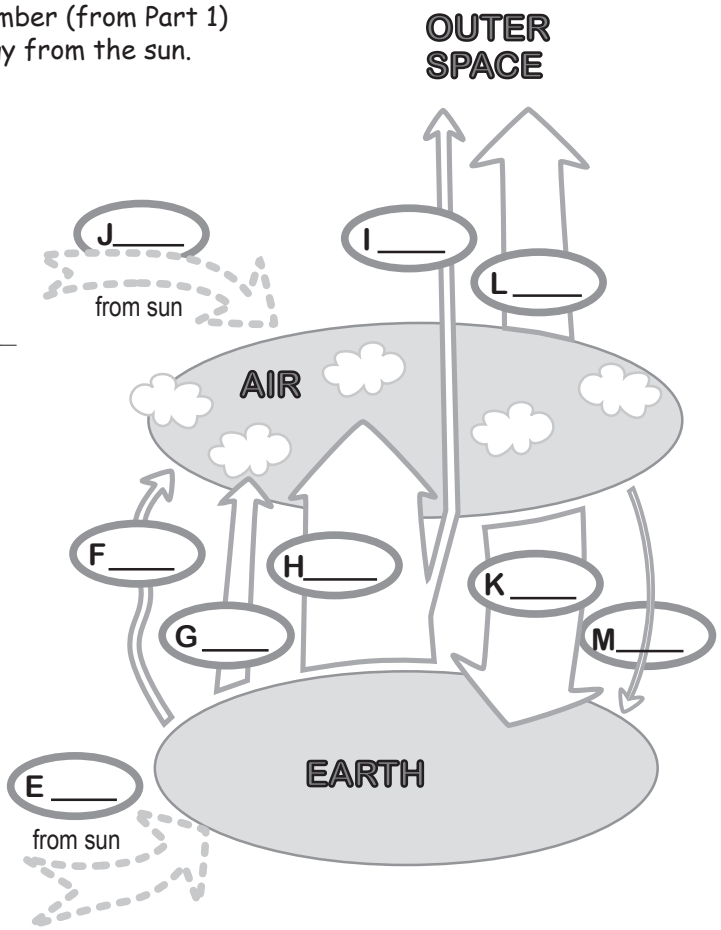
Write that 22 on line J.

11. It also gets energy from the earth:
6 parcels by heating the air (Line F)
25 by evaporating water (Line G)
105 by longwave radiation (Line H)

Write the total here _____
Add the 22 coming from the sun _____

12. This total is the amount of energy coming into the atmosphere. Satellites record 58 parcels of radiation going out from the atmosphere to outer space. (Clouds are colder than the ground. For that reason, the air does not have to radiate as much energy per day as the ground.)

What arrow on the diagram represents the radiation going from the air to outer space ?
Circle: H I J K L
Write 58 on that arrow.



13. The lower air is warm. Therefore, the atmosphere radiates 99 parcels down toward the ground. (That is actually the total downward radiation from all levels of the air).

What arrow represents downward radiation from the air? Circle: H I J K L M
Write 99 on that arrow.

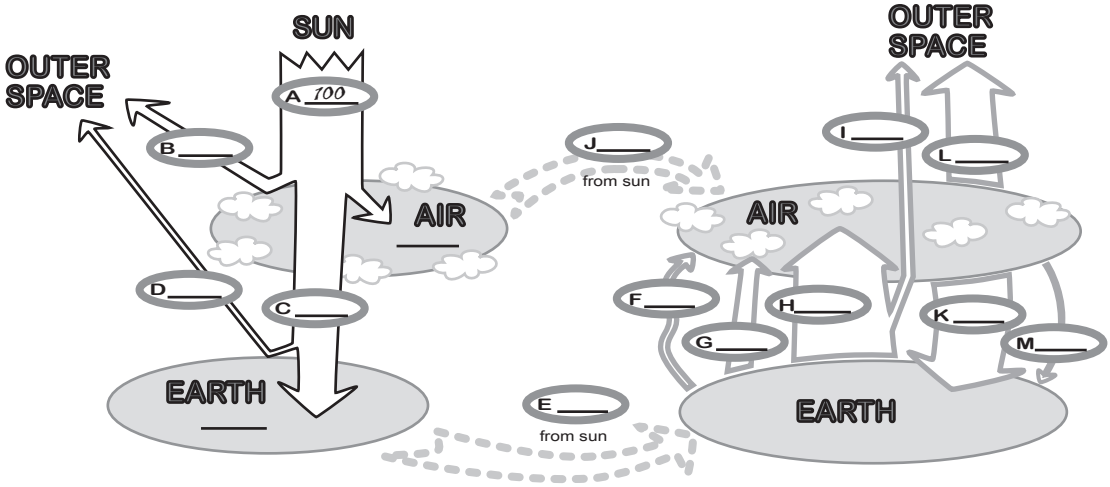
14. There is just one tiny arrow left. Rain might feel cold when it lands on your skin, but it actually carries some heat down from the air to the earth. It just feels cold on your skin because your skin is warmer than the average temperature of the earth.

What arrow represents the movement of heat in rain and snow? Circle: H I J K L M
Write 1 on that line.

15. Now let's review by working out the energy balance for the atmosphere.

INCOMING		OUTGOING	
Shortwave radiation from the sun	22	Longwave radiation to outer space	___
Heating of air by the warm ground	6	Longwave radiation down to the ground	___
Evaporation of water	25	Precipitation down to the ground	___
Longwave radiation from the earth	105		
TOTAL	_____	TOTAL	_____

Earth's Energy Budget: Part 4 - Human Activity



Now let's put the whole diagram together. Remember that every number is a global average and is likely to be different in different places. That is one reason why it is hard to measure the importance of human activity in causing changes in this huge and complicated system. Nevertheless, it is clear that human activity can alter some parts of the system.

16. For example, jet airplanes flying high above the ground can make high clouds that reflect some of the incoming sunlight. *Circle the arrow(s) that might change: A B C*

17. What human activities might change the amount of reflection from the ground (arrow D)?
___ cutting rainforest ___ plowing soil and planting wheat
___ setting dry grass on fire ___ removing snow from streets and driveways
___ doing something that might cause the polar icecaps to melt

18. If you marked all of the lines on question 18, you are right. The big questions, however, are "How much?" and "Which of these is the most important?" What do you think?

19. What human activities might change the amount of energy that goes up by evaporation? What effect could that have on the amount of cloud in the sky?

20. Many scientists think that the biggest impact is from burning fossil fuels like coal and oil. Burning puts carbon dioxide into the air, and carbon dioxide traps more of the radiation that goes up from the ground surface. *Circle the arrow(s) that gets bigger: H I J*

21. The changes described in questions #19 and #20 tend to make the lower air warmer.
Circle the arrow(s) that might get bigger as a result: C D K L M
What effects might that have on other parts of the system?