Adaptations to cold conditions in Mammals

Planning

In this investigation I will depict adaptations/features, which mammals in cold places have, to reduce heat that they lose.
Bigger animals have greater volume to carry out cellular respiration to produce heat. Cellular respiration is food (glucose) + Oxygen → Carbon Dioxide + Water +Energy (heat). More cells = Big volume, the greater the volume, the more amount of heat loss is reduced.
Smaller animals have larger surface area for them to lose heat to acclimatize to their hot climate.
Large mammals have small surface area to volume ratio whereas smaller mammals have a large surface area to volume ratio. This table shows my observation is accurate.

Cube size	Surface area(cm2)	Volume(cm3)	Ratio(surface area/volume)
1	6	1	6
2	24	8	3
3	54	27	2
4	96	64	1.5
5	150	125	1.2
6	216	216	1
7	294	343	0.9
8	384	572	0.75
9	486	729	0.7
10	600	1000	0.6
150	135,000	3,375,000	0.04

150 is the cube size of a polar bear!

If the cube size is 1 the ratio of surface area to volume is 6. If the cube size is 10 the ratio of surface area to volume is 0.6.
Judging by this evidence, you can tell that as the cube size is augmenting the ratio of surface area to volume is declining.
The ratio of a polar bear – whose cube size is 150 – is very small; therefore its volume is prodigious. As the volume is immense, it requires a lot of cells to respire, make cellular respiration and therefore producing heat. The lizard has a larger ratio than a polar bear resulting in a smaller volume. The lizard does not need a big volume because it lives in a desert and it needs to lose heat not make heat. The lizard loses heat mainly by its skin.

Noticeably, this experiment cannot be done using real life-sized animals. We will be able to use different laboratory equipment.
The apparatus being used is different sized beakers. The larger beaker characterizes the polar bear because it has a small surface area and a big volume because it's comparable to a polar bear.
The small beaker will represent the lizard because it has a small volume and a large surface area, which is similar to the lizard.
A thermometer will be used to measure the temperature of the boiled water in the beakers before/after the experiment, to see which beaker lost the most heat.
To confirm the theory that the larger the surface, the more heat will be lost, we must measure the surface area with a ruler before adding the boiled water into the beaker.

Prediction

I predict that the smallest piece of apparatus will have the largest drop in temperature because it has the biggest surface area to volume ratio. I am now going to support my prediction with the conduction, convection, and radiation theories.
In conduction the air particles in the room move around at random. Some of the particles will collide with the wall. Energy is transferred to the wall particles. The energy passes through the wall from particle to particle. The outermost wall particle collides with an air particle. The air particle moves away, taking the heat energy with it.
In convection the water at the base of the beaker heats up and expands.
This lowers its density so it rises; colder water sinks to replace it.
This up + down movement of fluid is called convection current.
Radiation does not need particles, every object sends out infrared radiation, hot objects send out more infrared radiation. In this case the beaker will be hot and therefore send out more infrared radiation, which will result in losing heat.

The factors that I will keep the same to make this a fair test are the start temperature, size of beaker and time, the volume of water in beaker should stay constant, the beaker should be the same material, and the position of the thermometer should stay the same.
We will do the experiment at least twice to get an average and the accuracy will increase.
We will not take the temperature every 10 seconds because it will be difficult and we only have one thermometer.

I will measure the temperature every minute for 20-30 minutes. The reason that I will not measure the temperature every 5 minutes is because that is too long of an interval.
The calculation I will use for the surface area and volume of the apparatus is:
Surface area of beaker / 3.142 (pi) x radius squared + 2 x radius x 3.142 (pi) x height.
The calculation I will use for the surface area/volume ratios is:
Volume divided by 3.142 (pi) x radius squared x height.

Method

First of all I will start by collecting any equipment and apparatus that is required for this experiment to proceed. I will need a thermometer, three different sized beakers (250 ml, 100 ml, and 25 ml), boiling water and finally a stopwatch.
I will then pour the boiling water into the right beaker and measure the temperature instantly, record it in a table and start stopwatch, stop every 1 minute and measure the temperature and record it. Whilst temperature is not decreasing, then start with next sized beaker.

Safety Rules

- No running in the laboratory.
- The experiment must be done standing up.
- Stools should be tucked under the table.
- Bags must be under the table also.
- You should handle boiling water carefully.

Surface Area of the 25 ml beaker = $\pi r^2 + 2r\pi h$

Therefore=π x 1.55 (squared) + 2 x 1.55 x π x 5.2

Which = 58.2 cm cubed

Surface Area of the 100 ml beaker = $\pi r^2 + 2r\pi h$

Therefore= π x 2.75 (squared) + 2 x 2.75 x π x 7.3

Which = 149.9 cm cubed

Surface Area of 250 ml beaker = $\pi r^2 + 2r\pi h$

Therefore= π x 3.9 (squared) + 2 x 3.9 x π x 9.5

Which=280.6 cm cubed

Volume of 25 ml beaker = $\pi r^2 h$
Therefore= π x 1.55 (squared) x 5.2
Which = 39.2 cm cubed

Volume of 100 ml beaker = $\pi r^2 h$
Therefore= π x 2.75 (squared) x 7.3
Which = 173.4 cm cubed

Volume of 250 ml beaker = $\pi r^2 h$
Therefore= π x 3.9 (squared) x 9.5

Which = 454 cm cubed

Surface Area / Volume Ratio for 25 ml beaker = 58.2 divided by 39.2, which = 1.5

Surface Area / Volume Ratio for 100 ml beaker = 149.9 divided by 173.4, which = 0.9

Surface Area / Volume Ratio for 250 ml beaker = 280.6 divided by 454, which = 0.7

Heat Loss = (start temp – final temp for each beaker)

25 ml beaker heat loss = 79°C - 41°C = 38°C

100 ml beaker heat loss = 82°C - 47°C = 35°C

250 ml beaker heat loss = 84°C - 53°C = 31°C

Analysing Evidence

My results show that as time increases the temperature decreases. To support this argument, I can see that in my graph in 2 minutes the temperature is 84°C – for the 250 ml beaker – and at 18 minutes the temperature was 55°C for the 250 ml beaker.
The 25 ml beaker showed the greatest loss in temperature, 79°C - 41°C, which is 38°C heat loss.
The 250 ml beaker showed the least heat loss, 84°C - 53°C, which is 31°C heat loss.
The drop in temperature was fastest during the first 5 minutes. The temperature fell because heat was lost by conduction.
I predicted that the larger the surface area the more heat could be lost by conduction, convection, and radiation.
These results were as I predicted. This supports my knowledge of special adaptations of mammals to cold conditions because the largest surface area/volume ratio will lose heat the quickest as its surface area allows more heat to be lost through conduction, mammals in cold climate gain heat due to their large volumes and the increased number of cells available for cellular respiration which makes heat for the mammals.

Evaluation

The method was appropriate because real life-sized animals cannot be used for this experiment. It was reliable because it was according to plan and it was accurate. There were some sources of error such as movement of thermometer, wrong timing. We could have paid more attention the clock because it was only 10 seconds interval. We should have held the thermometer in the middle of the beaker without moving it. I did not have any unexpected results. I have sufficient results to draw valid conclusions for this experiment, and this experiment only.

To increase the reliability of my results I could have done the same experiment using computer-aided temperature sensors.