Lab # 11
Homeostasis and Temperature Regulation

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Aim:
To observe whether a body in water loses heat energy faster then a body in air.

Hypothesis:
When a person goes swimming, they begin to feel cold faster then a person standing on the outside of the pool. This is due to the nature of conduction, convection and heat. Convection is the transfer of heat energy in a gas or liquid by movement of currents. Conduction is the transfer and distribution of heat energy from one atom to another. I hypothesize that a body in water would lose heat energy faster then a body in air of the same temperature, and that the rate of heat loss of the body in water would be around double that of the body in air. The molecules in a liquid, such as water, are far closer together then the molecules of a gas. This would mean that the water molecules would be in closer contact with the body, thus removing more heat, at a faster rate. Heat always moves from a warm object to a cooler object until the temperature of the two objects becomes equal. For a warm body in water, this means that the heat energy would be draw away from it rapidly in an attempt to raise the temperature of the water. As heat leaves the body into the surrounding molecules, the heat is passed along through convection and conduction, passing from one molecules to the next in quick succession causing the heat to be lost from the body at a high rate. In a gas, this process of losing heat energy would not be as fast as not as many molecules would be touching the body, thus would not be able to draw energy from it. Thus, the withdrawal of heat energy form a body would be much faster in a liquid then in a gas.

Apparatus:
- 2 Large beakers
- 10 Boiling tubes
- Boiling tube rack
- Bunsen burner
- Water
- Tripod
- Gauze
- Thermometers
- Stop watch
- Goggles
- Tongs
- Measuring cylinder

Method:
1) Heat 200 ml of water to around 80ºC in a large beaker
2) Fill another large beaker with water, measure its temperature
3) Using tongs, pour 25 ml of hot water into 4 boiling tubes, label each and measure its starting temperature.
4) Place 2 of the boiling tubes in the beaker containing water
5) Place the other 2 boiling tubes in the rack, be sure that they are not touching
6) Measure the temperature of each boiling tube every 30 seconds for 4 minutes
7) Repeat until you have enough results

Variables:
Independent: If the body (boiling tube) is surrounded by a body of air or of water.

Dependent: The rate at which heat is lost from the body

Controlled: The volume of water in each boiling tube
Times at which temperatures are measured
Room temperature
Water temperature

Data collection:
Table 1 shows the results obtained for the change in temperature of the boiling tubes surrounded by a body of air, over a period of four minutes.

Table 1, results for the boiling tubes in the control group (surrounded by air).

	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**
1	67.0	65.0	63.0	62.0	61.0	60.0	58.0	57.0	56.0
2	68.0	68.0	65.0	64.0	62.5	62.0	60.0	59.5	59.0
3	69.0	65.0	64.0	63.0	62.0	61.5	60.0	59.0	58.5
4	72.0	70.0	69.5	68.5	67.0	66.0	65.0	64.5	64.0
5	73.0	72.0	71.0	70.0	69.0	68.0	67.5	66.0	65.0

Table 2 shows the results obtained for the change in temperature of the boiling tubes surrounded by a body of water, over a period of four minutes.

Table 2, results for the boiling tubes in the experimental group (surrounded by water).

	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**
6	65.0	51.0	46.0	41.0	37.0	35.0	34.0	32.0	30.0
7	64.0	52.0	44.0	39.0	36.0	34.0	33.0	32.0	31.0
8	62.0	51.0	41.5	36.0	33.0	31.0	29.5	29.0	28.0
9	69.0	54.0	47.0	43.0	40.5	39.0	38.0	37.0	36.0
10	73.0	54.5	48.5	46.0	44.0	41.5	40.0	38.0	37.0

Table 3 shows the change of heat of the water baths that test tubes 6-10 were placed in for the experiment.

Table 3,

	Before	**After**
6	27.0	29.0
7	26.5	29.0
8	26.0	28.0
9	27.0	30.5
10	27.5	31.0

Data Analysis + Calculations:
In order to see what the rate of heat loss was, it is necessary to manipulate the data, finding the overall loss of heat for each boiling tube, find the average heat loss for the two conditions and to then find the rate at which heat was being lost.

<u>Finding the overall loss for each boiling tube:</u>

Table showing overall loss (ºC) in temperature for boiling tubes in air over a period of four minutes:

	Before	**After**	**Overall loss**
1	67.0	56.0	11.0
2	68.0	59.0	9.0
3	69.0	58.5	10.5
4	72.0	64.0	8.0
5	73.0	65.0	8.0

Table showing overall loss (ºC) in temperature for the boiling tubes in water over a period of four minutes:

	Before	**After**	**Overall loss**
6	65.0	30.0	35.0
7	64.0	31.0	33.0
8	62.0	28.0	34.0
9	69.0	36.0	33.0
10	73.0	37.0	36.0

The average heat loss for each condition:
Also seen in Graph 2 (page 5)

AIR:

$$\frac{11.0 + 9.0 + 10.5 + 8.0 + 8.0}{5}$$

= 9.3

WATER:

$$\frac{35.0 + 33.0 + 34.0 + 33.0 + 36.0}{5}$$

= 34.2

This shows that the boiling tubes lost an average of 9.3ºC in four minutes in air and 34.2ºC in four minutes in water.

Rate of loss:
The rate of loss is the speed at which heat is lost in either condition.

AIR:

$$\frac{9.3\ ^\circ C}{4\ mins}$$

= 2.33 ºC/min (or 0.039 ºC/sec)

WATER:

$$\frac{34.2\ ^\circ C}{4\ mins}$$

= 8.55 ºC/min (or 0.14 ºC/sec)

Conclusion:
From this experiment it is obvious that the average rate of heat loss from a body is far greater in water then it is in air. The theories of conduction and convection being the cause for this rapid loss of heat energy are therefore correct. Surrounded by water, a body is bombarded by molecules of water which remove heat energy from the body through conduction, and pass it along to the neighboring molecules in an attempt to equalize the temperatures of the body and the water. At the same time the heat that is removed from the body is passed through convection throughout the water body, causing more of the cooler molecules to move into positions where they can obtain heat, thus causing the rate of heat loss to be rapid. In addition to this the molecules are close together in water meaning that the rate of transfer is relatively fast. From this experiment we see that the

rate of heat loss from a body in water is around 8.55 ºC per minute. However, in air, the molecules are not as closely packed as water molecules, thus they bombard the body less, therefore the rate of loss is slower in air then it is in the water. This experiment states that the rate of loss of heat from a body which is suspended in air is around 2.33 ºC per minute. From these values, it is evident that the heat loss in water is around 3.7 times faster then heat loss in air. Thus, the hypothesis is correct is saying that we lose heat faster in water then in air.

Evaluation:

Although this experiment proves that the hypothesis is correct, and gives realistic records of the rate of heat loss from a body, it is not totally correct and accurate, and many things may have occurred during the course of the experiment that may have caused the results to be biased or inaccurate.

Firstly, in the beginning stages of the experiment, the air conditioning was blowing right on my experiment, thus the wind could have caused the rate of heat loss from the boiling tubes in air to have been greater. The wind would have cooled the air and blown more molecules against the tube, causing more heat to be taken from the tube and lost to the atmosphere. This would have caused the first tests to have inaccuracies. The air conditioning would have had a lesser effect on the tubes in the water baths, as the wind would not be blowing directly on the tubes, but on the sides of the water bath, thus it would not have affected the number of molecules bombarding the sides of the tube.

Secondly, one of the factors that most likely affected the readings for the tubes in the water baths, was the fact that the temperature of the water bath itself increased during the course of the four minutes that the tubes were in for. This rise in temperature of the bath would have caused heat to be removed less rapidly from the tubes. The closer the two temperatures get (the temperature of the body and the temperature of the bath), the slower the rate of heat loss, as the whole purpose of conduction and convection is to get the two bodies to have the same temperature. Thus, if the water baths heated up, the rate would become slower, not stay a constant, therefore the readings of the water bath tubes would have been affected.

Thirdly, by having tubes near each other in the racks, or in the baths, the heat that leaves the one tube will cause the second tube to remain warmer for longer. This is seen in nature a lot, such as when penguins huddle together in the ice to form a huge mass of bodies, this keeps them warm as the air between them warms up and therefore keeps them warm. The principal is the same with the tubes, if they are near they will warm each other, slowing the rate of heat loss.

Next, I did not think to use covers to cover the open tops of the boiling tubes. Heat would have been lost rapidly through the open mouth of the boiling tubes through means of convection. This would have caused the rate of heat loss to increase in some cases and thus lead to more inaccuracies in the procedure.

Lastly, this experiment cannot be seen as valid for people. Although it is seen that the rate of heat loss is far greater in water then it is in air, the rate of heat loss obtained is unrealistic for humans. Our bodies would never reach temperatures similar to those of the starting temperatures for my experiment. Seeing that our body temperature is around 37ºC, and room temperature is around 25 ºC, the rate would be a lot slower as the temperatures are not that different. Since the point of conduction, convection and radiation is to equalize the two bodies' temperatures, the rate would be very slow in air since they are so similar, and as for water, it would still be faster then the rate of heat loss in air but it would be no where near the number obtained in this experiment. When we go swimming we generally remain in the pool (which is around room temperature) for at least half an hour, if the rate of heat loss obtained from this experiment were true for humans, we would freeze before the half hour were over. Thus it is unrealistic to think that these values are valid in our everyday lives. They may be valid for this experiment but cannot be generalized.

This experiment could be improved in many ways. One of which would be to use plastic covers on the open mouths of the boiling tubes so that as little heat as possible is lost through the lid, especially in the case of the boiling tubes in water.

Another way in which we could improve this experiment would be to only do one boiling tube at a time, ensuring that no two boiling tubes heat each other up, thus slowing the rate of heat loss. Starting all boiling tubes at the same temperature would also increase the simplicity of the readings of this experiment, making it easier to compare the results obtained and the readings. However, this is not always easy to do, hence the reason I did not do it!

Bibliography:

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Conduction, convection and radiation, 11/09/04
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