[illegible]

[illegible]m

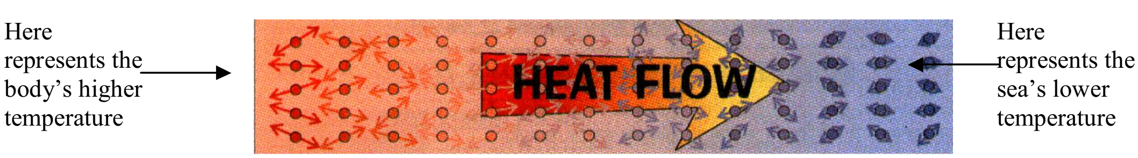
In this experiment I was presented with a basic model of the body an asked to investigate how the temperature of the sea affects the rate of heat loss from the body. Through a series of tests I am to find out if there is a relation between the two.

There are several factors that affect the rate of the temperature dropping, such as the amount of water representing the body; the amount of water the model sea consists of, the starting temperature for both the 'sea' and the 'body'. I will keep all of these, except the sea temperature, constant. I will vary the temperature of the sea from 30^{o}C to 3^{o}C. I will measure the temperature at five different values of sea temperature to give an overall impression. I will not be repeating the experiment at each value as in the pilot I was getting agreement of result between half a degree. I judged that the benefits of having a set of different results to allow for averaging, when the results were of such close value in the first place, did not validate the time that it would have taken.

[illegible]

I believe that as the temperature of the sea gets lower hypothermia will occur at a faster rate. This is justified by the explanation that thermal energy always flows from hotter material to cooler material. This energy causes the water molecules to move faster, showing up as an increase in temperature. This higher value of energy than the surroundings tends to get dissipated and shared with the surroundings lead to a constant temperature in the local environment.

This leads me to say that the temperature of the sea directly affects the rate of hypothermia. As the temperature of the sea rises, the rate of heat loss from the body decreases. This is because the 'sea' needs less energy to reach its specific heat capacity.



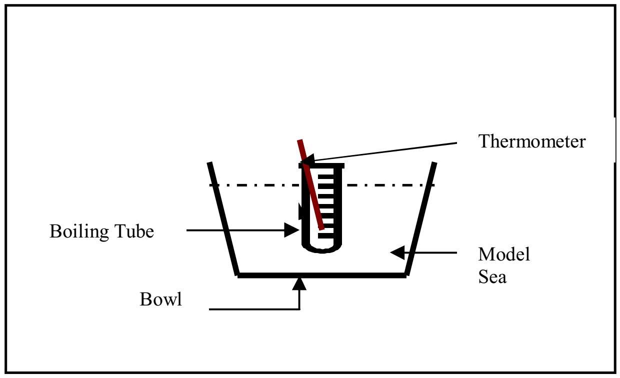
The main heat loss would be due to convection as that is the most effective way for transferring energy through the sea that surrounds the body. The extra energy drives the molecules into moving faster. The molecules move away carrying with them the thermal energy to cooler areas. This means that the temperature of the sea is directly proportional to the rate of hypothermia. As the temperature of the sea drops the rate of hypothermia increases. This is because the sea is in need of more energy to reach its specific heat capacity.

Conduction is the only way for heat to be passed along in solids. In metal this would be a rapid process due to the thermal energy being carried through by the 'free' electrons. This however is not the case in non-metals, such as the glass test tube, in which there are no free electrons to carry the energy through. This results in a slower procession of heat but it is the only way. This makes the test tube act as an insulating material between the water representing the body and the colder water representing the sea. The time taken for heat to pass through is not as long as it might have been because of the thickness of the tube. The relative rapidness- when compared to other non-metals- is due to the fact that it is not very thick. Once the energy is passed to the model sea then it would be carried away much more effectively by convection. This is due to the molecules that gain the extra energy moving away from the hotter region to a cooler one spreading the heat more quickly.

However for this experiment I what I am measuring is actually the rate of convection, how fast the sea removes the thermal energy from the body as the temperature of the sea changes.

Equipment & Materials

The apparatus should be set up as shown



- 1 x boiling tube
- A stopwatch
- Water
- 2 x thermometers
- 1 x 10 cm^3 measuring cylinder
- 1 x 100 cm^3 measuring cylinder
- A bowl
- 1 x water heater

Method

1. Heat 100 cm^3 of water to 30°C. then pour into the bowl. This will represent the sea.
2. Place 10 cm^3 of water into the boiling tube- the water temperature here should be 37°.
3. Start the stopwatch and measure temperature every 30 seconds record the results in a table like the one shown below:

Time (seconds)	Temperature
0	37
30	33

TAKE CARE AS HOT WATER CAN BURN!

4. You may, if you wish, repeat each part multiple times and work out an average but as I will explain in my results section that proved to be unnecessary in my experience.
5. Repeat the above steps but change the sea temperature to 4 others of your choice. I chose 10°, 21°, 17° and 3°.

Results (part 1)

Here are the results I got for that experiment.

SEA TEMP= 30 °C	
Time	Temperature
30	33
60	32
90	32
120	31
150	30
180	30
210	30
240	30
270	30
300	30
SEA TEMP= 21 °C	
Time	Temperature
30	31
60	28
90	26
120	24.5
150	24
180	23
210	22
240	21.5
270	21.5
300	21

SEA TEMP= 17 °C	
Time	Temperature
30	29
60	27
90	26
120	24
150	23
180	22
210	21.5
240	20.5
270	19
300	18

SEA TEMP= 3 ºC	
Time	Temperature
30	22
60	16
90	15
120	13
150	11
180	9.5
210	8
240	6.5
270	5
300	4

SEA TEMP= 10 ºC	
Time	Temperature
30	24
60	23
90	21
120	19
150	17
180	11
210	11
240	10.5
270	10.5
300	10

I did not repeat each experiment a number of times as when I first started I was getting agreement between the results to within 0.5 of a degree, so I decided to only do each experiment once and let the graph do the averaging.

I also decided to repeat the experiment but add one more thing: stirring the water in the boiling tube to give me a more accurate measurement I was careful to keep all other variables the same so the experiment would be fair. Unfortunately I was not able to use exactly the same sea temperatures but I was able to use very similar ones for the comparison to be valid.

Results (part 2)

These are my results the second time round:

SEA TEMP= 24 ºC	
Time	Temperature
30	31
60	28
90	27.5
120	27
150	26.5
180	26
210	25
240	24
270	24
300	24

SEA TEMP= 20 ºC	
Time	Temperature
30	30
60	29
90	27
120	24
150	23
180	22
210	21
240	20.5
270	20
300	20

SEA TEMP= 15 ºC	
Time	Temperature
30	30
60	26
90	22
120	19.5
150	17
180	16
210	16
240	15.5
270	15
300	15

SEA TEMP= 12 ºC	
Time	Temperature
30	26
60	24
90	21
120	20
150	19
180	18
210	16
240	15
270	14
300	12.5.

SEA TEMP= 5 ºC	
Time	Temperature
30	27
60	18
90	15
120	13
150	10
180	8
210	7
240	6
270	5.5
300	5

Conclusion

My prediction was supported by my results (see evaluation), although the lines on the graph crossed on more than 1 place. Essentially I was correct in my assumptions leading me to this conclusion.

As the sea temperature gets lower, a body would reach a state of hypothermia quicker. This is because of thermal energy flowing from hot to cold. In the sea this would happen by convection as the extra energy drives the molecules into moving faster. The molecules move away carrying with them the thermal energy to cooler areas. This means that the temperature of the sea is directly proportional to the rate of hypothermia. As the temperature of the sea drops the rate of hypothermia increases. This is because the sea is in need of more energy to reach its specific heat capacity.

The opposite occurs as well, so as the sea temperature increases the rate of cooling decreases. This is explained well by likening this experiment to a slope where A is the starting temperature of the body, and B the starting point of the temperature of the sea. If the slope itself represents time- as in most of my results the body temperature dropped to be exactly the temperature of the sea. The steepness of the slope represents the difference in temperature between A and B. so if we assume that in the same amount of time A will always end up equal to B, and that B -the sea will not change in value, as it would not change in real life- will remain constant then if the time for the drop to occur is five minutes, the formula for average drop in temperature in seconds is $\frac{A - BX}{300}$. X is the number relating to which sea temperature it was (see diagram). A, the body temperature will of course remain the same at the start in all the experiments as it remains at 37 to represent the body's temperature. The diagram also demonstrates how the drop from A to B1 is much smaller than from A to B2, so the rate of hypothermia will have to be faster for A=B2 for the body temperature to equal the sea temperature at the end in both cases.

From the graph as well I can see that the ending temperature for the body is almost always the same as the sea temperature. I think this is because there is more sea than body so the ‘lost’ energy from the body is not enough to stop the hypothermia. Another observation is that the drop in body temperature is fastest at the beginning. This is explained by the kinetic theory, as the average value of kinetic energy is higher the molecules move faster and so there is a greater chance of a collision, giving a higher probability of thermal energy being passed on. As thermal energy always flows from hotter to cooler the body’s temperature decreases while the temperature of the sea increases. However because the sea is much larger than the body ideally its temperature would not rise.

Evaluation

I think that the vast majority of my results are accurate enough to be reliable. The experiment went well, especially with the repetition as that gave me a chance to compare the effects of ‘waves’ simulated by me stirring the model sea.

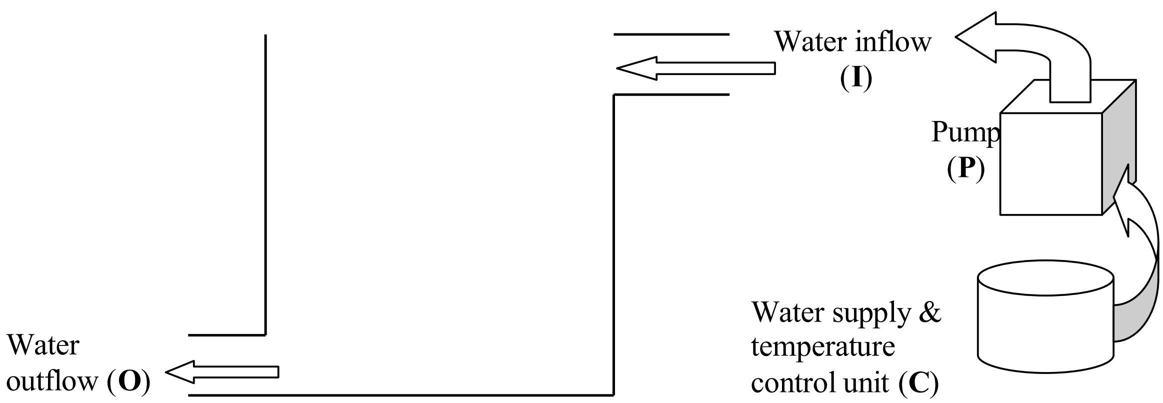
I knew that if the experiment went smoothly then none of the lines on the graph should touch, as the formula $\frac{A - BX}{300}$ would have produced straight lines. In reality, the gap between the temperatures of the sea and the body is greater at the beginning than later on, which should give a smooth curve. All the graphs would have roughly the same shape so none should have touched. Despite all of this, the lines on the graph did touch.

I have different theories that may aid in explaining these anomalies, one is that it could be human error in reading the temperature off the thermometer but I am quite sure this is not the case as I was careful to get the right result. If this was the case then to correct it the reading may need to be verified by several people to make sure. My second theory is that the starting temperature of the sea or the body was not what it was supposed to be. This may be the case as it was very difficult to get the right temperature due to the very crude methods we were required to use: mix boiling water with cold water and ice and hope for the best! In addition, I did not wait long enough for the temperature to be uniform throughout the mixture and I did not stir the mixture, suggesting that the starting temperature was gravely inaccurate. This could be corrected by using a more accurate way of heating or cooling the water to the previously specified temperature.

Another theory is that being human I would have slowed down the rate at which I was stirring the sea resulting in differing rates of cooling. To overcome the problem a mechanism to stir instead of a person to make sure that the rate of stirring is constant throughout a single experiment and for all the different starting temperatures. One other theory is that when the thermometer is removed from the test tube the reading would start to either drop or rise according to the temperature of the room. This could be avoided by using special extended length thermometers that would not need to be removed from the test tube to be read. The last theory I have to why that could have happened is that the use of different thermometers gives distorted view because each thermometer gives a varying result. I can support this theory by the fact that I did a small experiment at the end to check and found that no two thermometers gave the same reading. This problem presents the possibility of a compromise between the speed that the results could be acquired by and the c ost of the equipment. In my view to fully bypass this, a high tech thermometer would need to be used to give accurate readings and because it could be reprogrammed, all the thermometers could be co -ordinated to give the same reading for the same temperatur e. Alternatively, the same thermometer would have to be used to give a definitive and objective reading. However, this would be difficult to organise in a class situation.

This leads me to conclude that in order to minimise the probability of such errors and anomalies showing up the following enhancements should be made to the experiment:

- It should be carried out by a minimum of three people who should each personally verify each result.
- An automated set of thermometers would need to be used to provide accurate readings.
- Every result should be repeated three times to verify it.
- The water should be provided either by an accurate water bath or by a similar piece of equipment
- The stirring should be done by a mechanical automated instrument OR the two points above can be avoided by constructing a specific piece of equipment (see plan below):



This method has the additional bonus of providing a way to alter the temperature of the water and monitor it on a constant bases as well as removing the need for stirring the 'sea' because there already would be a constant moving of the water. This piece of apparatus would not need a pump to power the water out of it as well as into it because the pressure of the water, which increases as the depth increases, would be enough to force it out. The rate of outflow could easily be controlled by introducing a valve at point **O** and the inflow could be controlled by either the pump or, again, by the introduction of a valve at point **I**. This would provide very reliable results, which makes it suitable if accuracy is the top priority.

My results were, despite the earlier criticism, reliable enough for me to come to a conclusion. This means that a less expensive way to improve the quality of the results would be to simply repeat the experiment. An improvement that is also easier to implement would be to increase the relative size of the ‘sea’ compared to the body.