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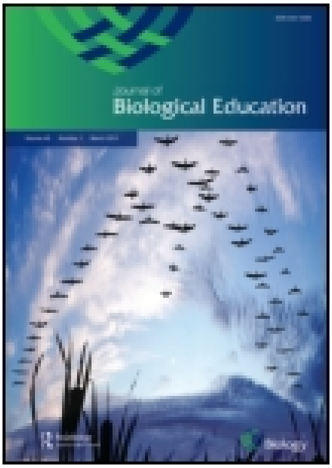

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Body size and temperature: an extended approach

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ropyl alcohol (10 per cent) and glacial acetic acid (10 per cent). We destain in a bath on a shaker or in a home-made syphoning apparatus (Lea and Hoare, 1978). Details of another simple destaining device have been published by Rushbrook (1979).

After staining and destaining gels may be inspected to determine the number of polypeptides. They may also be photographed (figure 3) and/or scanned. Molecular weights of unknown proteins may be estimated if marker proteins of known molecular weight are electrophoresed in the same gel. A calibration graph is prepared by plotting mobility of the marker proteins (distance travelled by given band/distance travelled by tracking dye) against log molecular weight.

Acknowledgements

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Body size and temperature: an extended approach

David Barrett

The standard Nuffield O-level practical can usefully be extended as described here

The *Revised Nuffield Biology Text 2* contains a section dealing with body size and temperature loss. The instructions require pupils to fill two tin cans of different size with hot water, and then to record the fall in temperature at five minute intervals for 30 minutes. For more able pupils an extended quantitative approach could prove more satisfying.

The 'beaker family' experiment

Three glass beakers of different size are taken: 'daddy', 'mummy', and 'baby' beaker. Hot water, of known temperature, is poured from a kettle into each beaker. The assumption is made that each beaker starts with water at the same temperature. As in the Nuffield Text, the fall in temperature is recorded at five minute intervals for 30 minutes. A graph of actual results is shown in figure 1. Pupils are then asked to calculate the surface area: volume ratio (SA:Vol) of each member of

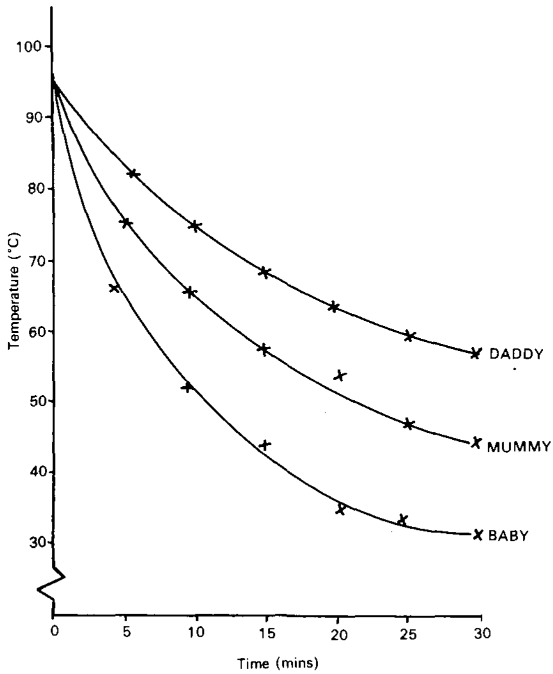

Figure 1 Temperature loss against time for each member of the beaker family.

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the beaker family using the 'water tube' as shown in figure 2:

volume $= \pi r^2 \times h$
surface area $= 2\pi r^2 + (2\pi r \times h)$

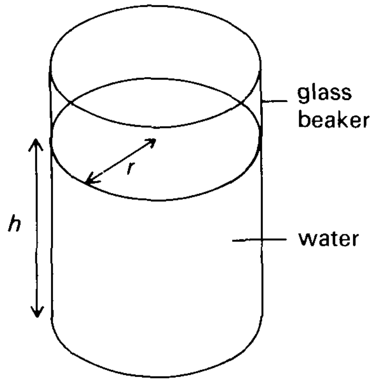

Figure 2 'Water tube' in glass beaker with radius *r* and height *h* dimensions as shown.

Figure 1 can now be discussed in terms of the relationship between temperature loss and SA:Vol ratios. A graph illustrating this relationship can be drawn as shown in figure 3.

A further extension of the experiment is to inform pupils that:

To raise 1 cm^3 of water 1 °C uses 4.2 joules of energy. Therefore, if 1 cm^3 of water falls in temperature by 1 °C then 4.2 joules of energy have been lost.

Pupils can now calculate the amount of energy lost by each member of the beaker family for the duration of the experiment:

Total energy lost (joules/30 min) = 4.2 × volume (cm^3) × drop in temperature (°C)

The average energy lost in kJ min^{-1}, and the average energy lost in kJ min^{-1} cm^{-2} can be calculated. Table 1 consists of actual results obtained by one group of pupils. It is from these results that the previous graphs were constructed. It is important to note that the assumption is made that heat is being lost equally over the entire SA of the 'water tube' which is, of course, not true. An opportunity exists here to discuss experimental design.

Pupils are surprised to discover that the bigger the

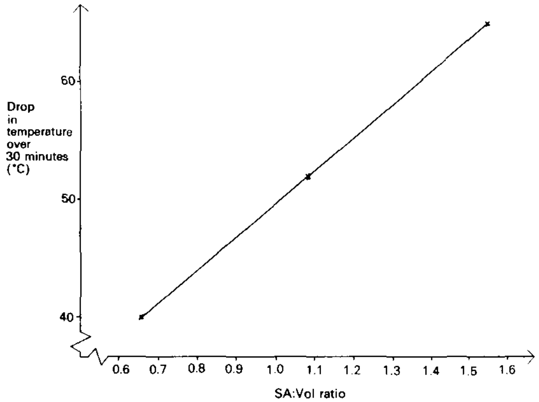

Figure 3 Graph showing the drop in temperature against SA:Vol ratio for each member of the beaker family.

beaker the greater the rate of energy loss *but* the smaller the rate of temperature fall.

The last column in table 1 indicates that the rate of energy loss per cm^2 of SA is about constant, as could be expected, and, as 'daddy' beaker has the largest SA, pupils understand why he should lose most energy. The problem arises in relating this observation to the knowledge that his body temperature falls the least. I have found that pupils are able to appreciate the explanation: daddy beaker loses more energy min^{-1} but a smaller fraction of his total energy, which means a smaller temperature drop. (The concept of temperature being related to the energy per atom.)

The instinct of pupils to treat temperature and heat energy as the same can be overcome by stressing the relationship:

Energy change = 4.2 × vol. × temperature change.

They may well have met this relationship in their O-level physics.

Acknowledgement

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Reference

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Table 1

Beaker	SA (cm^2)	Vol. (cm^3)	SA:Vol. (cm^{-1})	Total energy loss (J/30 mins)	Total energy loss (kJ/30 mins)	Average energy loss (kJ min^{-1})	Average energy loss (kJ min^{-1} cm^{-2})
Daddy	386	580	0.66:1	97,440	97.44	3.25	0.008
Mummy	146	135	1.08:1	29,484	29.48	0.98	0.007
Baby	57	37	1.54:1	10,101	10.10	0.34	0.006