SSERC Bulletin

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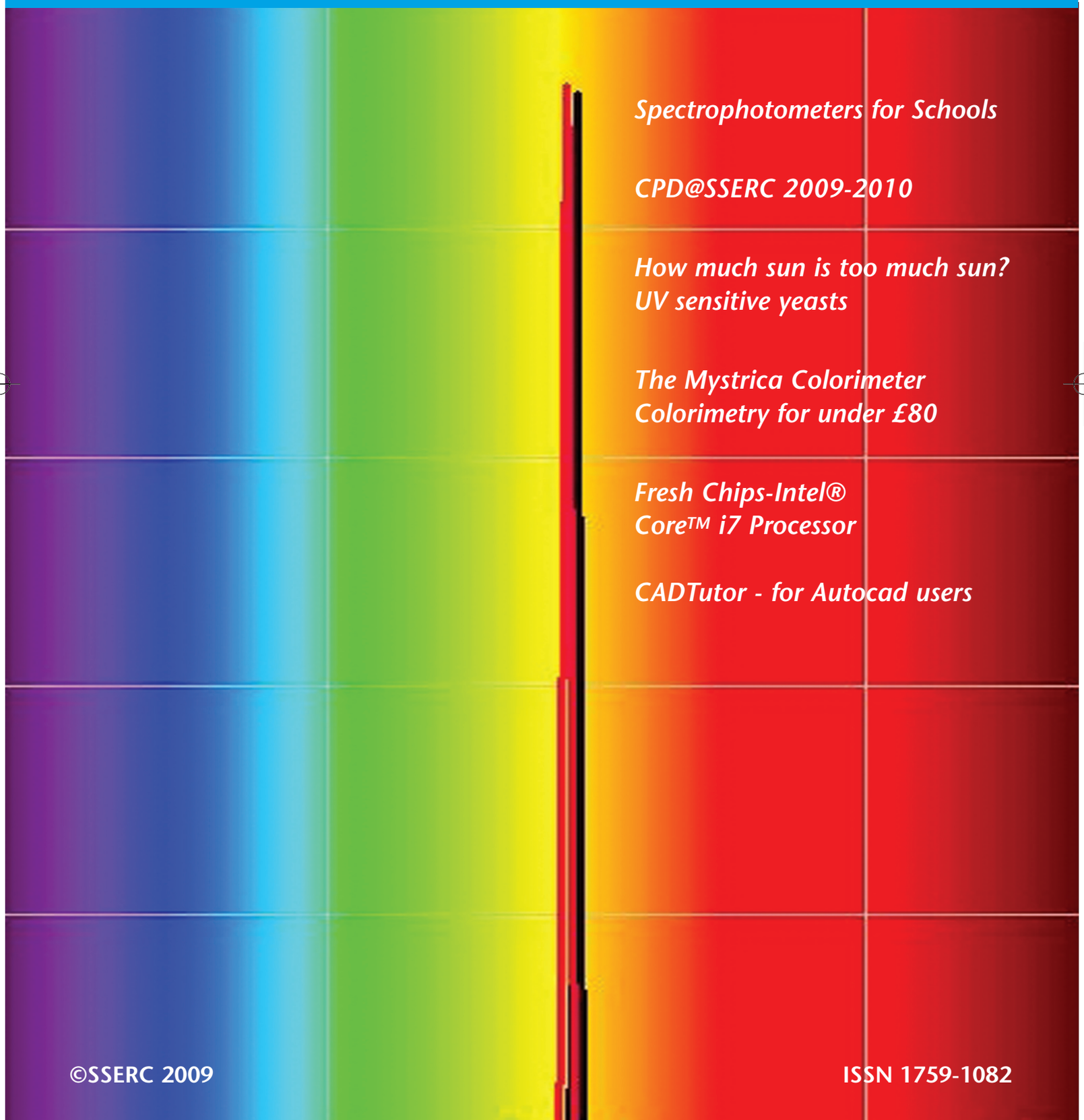
Ideas and Inspiration supporting Science & Technology for all Local Authorities



Spectrophotometers for Schools

CPD@SSERC 2009-2010

How much sun is too much sun?
UV sensitive yeasts

The Mystrica Colorimeter
Colorimetry for under £80

Fresh Chips-Intel®
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ISSN 1759-1082

Spectrophotometers for Schools

Here we review two spectrophotometers suitable for use in school science labs. Both connect to computers via the USB connection. The models we looked at were the *Red Tide* from Ocean Optics and the *SpectroVis* from Vernier. The Red Tide can also be used with a Pasco Xplorer GLX interface and the SpectroVis can connect to a Vernier LabQuest. These handheld interfaces were reviewed in SSERC Bulletin 226 [1]. They have their own LCD screens and can display tables and graphs without the need to connect the spectrophotometers to a computer.

SpectroVis

***Figure 1** - SpectroVis spectrophotometer.*

The SpectroVis (Figure 1) is available from Instruments Direct Services Ltd [2]. At the time of writing it cost £382, plus £66 for the optional optical fibre probe (Figure 2). It works with Logger Pro 3 software which is available separately.

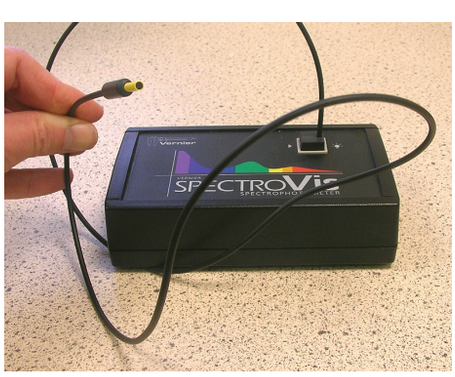

***Figure 2** - SpectroVis with optional optical fibre probe.*

The manufacturers claim a wavelength range of 400 nm to 725 nm, with a resolution of 3 nm. Our first test was the examination of the spectrum from a sodium lamp. Figure 3 shows the full spectrum whilst Figure 4 is a zoom on the yellow lines at 589.0 nm and 589.6 nm. Neither of the spectrophotometers we tested could resolve the sodium doublet into two discrete peaks. The results agree with the manufacturer's claims.

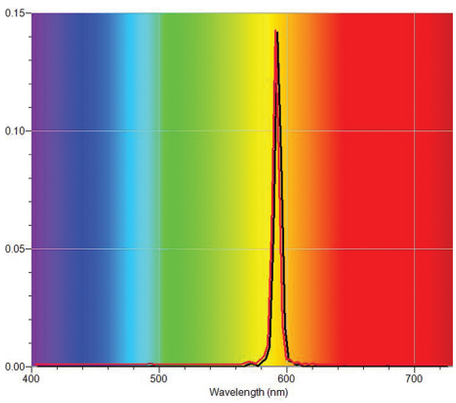

***Figure 3** - Spectrum from sodium lamp (SpectroVis).*

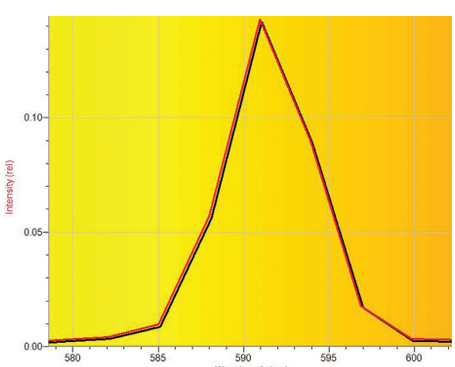

***Figure 4** - Zooming in on the sodium yellow line (SpectroVis).*

The SpectroVis also has a built-in cuvette holder (Figure 5) and white LED light source.

***Figure 5** - Placing a cuvette in the cuvette holder.*

This allows for absorbance and transmittance experiments to be carried out. A calibration procedure is described in the manual that comes with the spectrophotometer. We placed two different green food dyes (Figure 6) into cuvettes. Both were made by adding Supercook food colouring to water. This is readily available in supermarkets. In one case, green food colouring was used. In the other, the green colour was made by mixing yellow and blue dye.

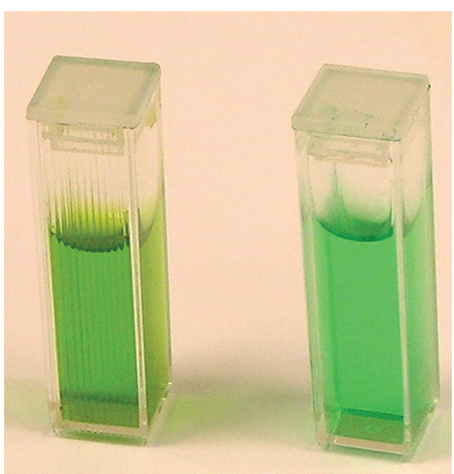

***Figure 6** - Food dyes in cuvettes.*

The absorbance and transmittance graphs are shown in Figure 7 below.

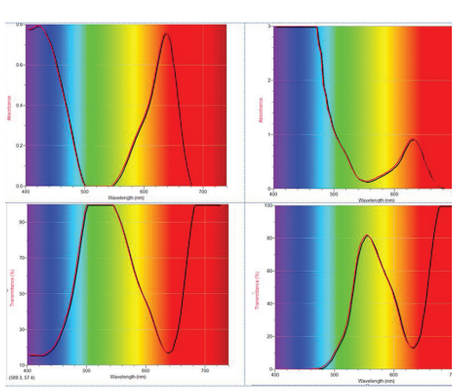

***Figure 7** - Absorbance (top) and transmittance graphs for two dyes.*

These features allow a number of experiments to be carried out, including investigating Beer's Law and forensic activities.

Some time ago, the senior physicist at SSERC got built for him some ping-pong ball colour mixers based on a design by Gorazd Planinsic of the University of Ljubljana [3]. Figure 8 shows two of them.

***Figure 8** - Ping-pong ball colour mixers.*

When we examine their output with the spectrophotometer, the results may at first seem surprising (Figure 9).

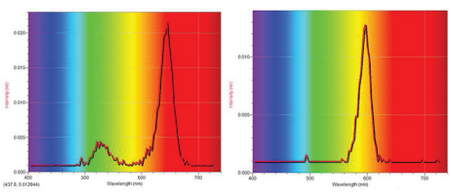

***Figure 9** - Examining the light from ping-pong ball sources.*

The balls appear to be the same colour, so why are the graphs different? The ball on the right contains yellow LEDs. As expected, there is a corresponding peak in the yellow part of the spectrum. However, the ball on the left contains red, green and blue LEDs but the blue one is off. In other words, we are comparing yellow produced by colour mixing with true yellow. This tells us something fundamental about colour mixing. It does not happen inside or at the surface of the ping-pong ball, or else both outputs would be the same. Rather, it takes place in the brain. *Colour mixing is biology, not physics.* Discuss.

Red Tide

The Ocean Optics Red Tide Spectrophotometer (Figure 10) is available from Feedback Instruments [4], Scientific and Chemical [5] and Timstar [6]. The typical cost is £795 for a "physics set" which consists of the base unit plus an optical fibre, or £1095 for the "chemistry set" which has no optical fibre but does have a light source and cuvette holder. Physics sets can be upgraded to chemistry sets and vice-versa. The range is said to be 350 nm to 1000 nm, with a resolution of 2 nm.

***Figure 10** - Red Tide spectrophotometer with optional cuvette holder (chemistry set).*

Once again we examined the spectrum from a sodium lamp (Figures 11 and 12).

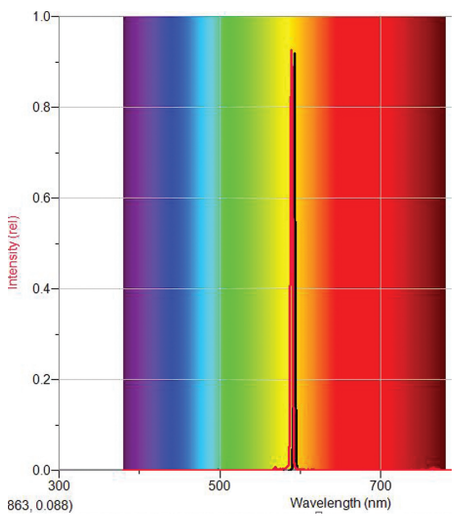

***Figure 11** - Sodium emission spectrum captured by Red Tide.*

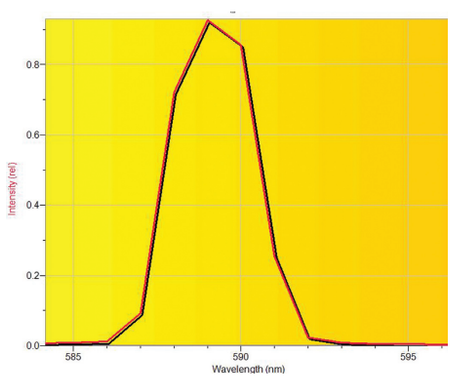

***Figure 12** - Zooming in on the sodium yellow line (Red Tide).*

The Red Tide works with Logger Pro 3 software but it also comes complete with a package called Spectrasuite. A Spectrasuite screenshot, showing a sodium absorption spectrum, is shown in Figure 13.

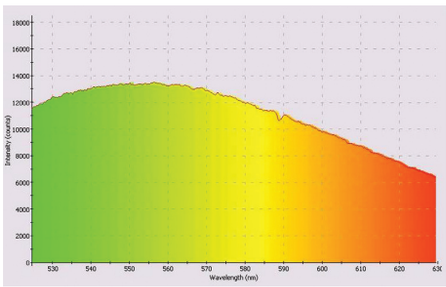

***Figure 13** - Sodium absorption spectrum. Note the wee nick in the spectrum at around 589 nm where most absorption takes place.*

Conclusion

Comparing the spectra produced by each device, we see that the Red Tide has the greater range and better resolution. It is also considerably more expensive. It is unlikely that many individual school departments could buy either model of spectrophotometer from their annual capital allowance. That said, should biology, chemistry and physics departments pool their resources, buying one becomes much more of a possibility. Since both devices offer possibilities for interesting, innovative practical work in all three sciences, we hope that they do find their way into classrooms.

Appendix

Testing the resolution of a spectrophotometer is not without its problems. The situation is complicated by the fact that no light source, not even a laser, is truly monochromatic. This makes it hard to determine whether the broad peaks we see are due to the measuring instrument, the light source or both. Look at the images below (Figures 14 and 15).

***Figure 14** - Spectrum from laser diode module (SpectroVis).*

We can see that the SpectroVis has a data point every 3 nm, whereas with the Red Tide, the resolution appears to be 1 nm. When quoting resolution, however, the Red Tide manufacturers state "2 nm, full width half maximum". As we ourselves would be inclined to do, they have derived their uncertainty from the width of the peak at half the maximum height (FWHM for short).

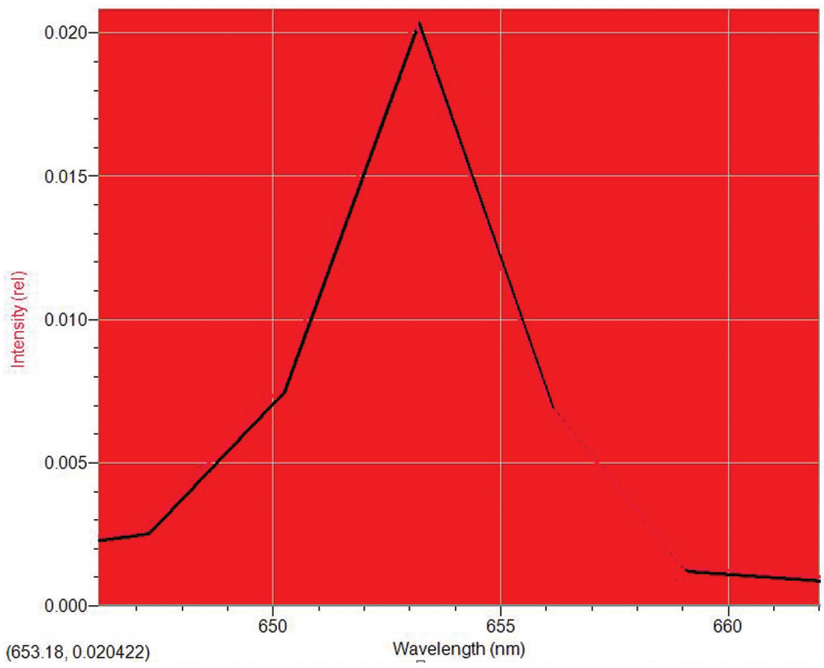

***Figure 14** - Spectrum from laser diode module (SpectroVis).*

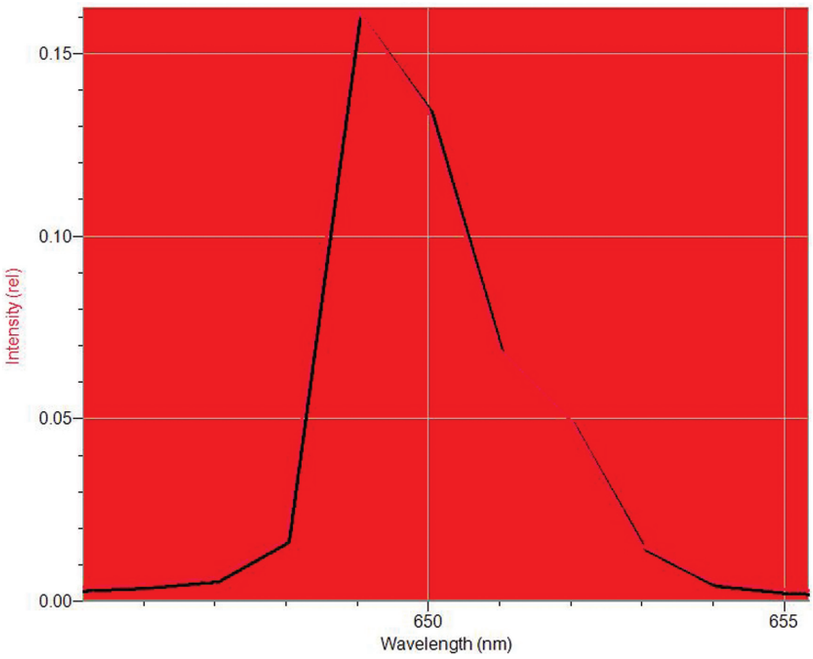

***Figure 15** - Spectrum from laser diode module (Red Tide).*

References

[1] http://www.sserc.org.uk/members/ SafetyNet/bulls/226/Interfaces.htm
[2] www.inds.co.uk
[3] The Physics Teacher, Volume 42, March 2004, page 138
[4] www.fbk.com/pasco/PASCO-UK-price-list.pdf
[5] www.timstar.co.uk
[6] www.scichem.com

Fresh Chips-Intel® Core™ 17 Processor

Fresh Chips

Intel® have recently launched its Core™ i7 Processor. As a result of changes in the architecture of the processor chip, the benefits are faster, intelligent multi-task applications. Within School Technology departments, obvious benefits will be when working with your favourite CAD/CAM/CAE packages, particularly when rendering or photo-editing.

Changes in the architecture of the i7 chip - considered to be some of the biggest changes in ten years, has enabled a more direct approach to memory access as indicated in the Table 1 together with a three channel memory controller access to the RAM (Random Access Memory).

This technology is not new, for example Pentium 4 processors had a 'Hyper-Threading' facility. The i7 processor has four independent CPU (Central Processing Unit) cores. HyperThreading makes use of a further four 'virtual' cores, in essence, the processor has eight CPU cores. Performance benefits of HyperThreading will vary depending on hardware and software used.

Intel extols the benefits thus - "With Intel Hyper-Threading Technology, highly threaded applications can get more work done in parallel, completing tasks sooner. With more threads available to the operating system, multitasking becomes even easier. This amazing processor can handle multiple applications working simultaneously, allowing you to do more with less wait time."

Name:	Core i7 processor
Launched:	End of 2008
Available:	Early 2009
Processor Provides:	Faster memory Hyper Threading Turbo mode / overclocking
New Architecture:	Allows the processor direct data access from the system RAM. The new memory controller has three channels which connect to the RAM, for this reason memory will likely be in groups of three, i.e. 3GB, 6GB, 12GB
Core Speeds:	2.93 GHz and 2.66 GHz
Processing Threads:	8 processing threads with Intel hyperThreading technology.

***Table 1** - i7 Processor Details*

Turbo Mode / Overclocking

With four physical cores on the i7 chip, the i7 has the ability to 'switch off' any un-used core, and is able to channel additional power to the cores in use, this is called 'overclocking' or turbo mode.

Many CAD applications are 'single threaded' and would benefit from overclocking. The speed of a single core can be boosted by 400 MHz in the turbo mode.

According to Intel the i7 represents a large leap forward in processing power and speed. Of course, processor prices are always initially high, but no doubt we'll look forward to purchasing our first i7 processor based system in the near future.

References

www.intel.com/products/processor/corei7/index.htm
www.intel.com/products/desktop/processors

CADtutor – a useful website for AutoCAD users – www.cadtutor.co.uk

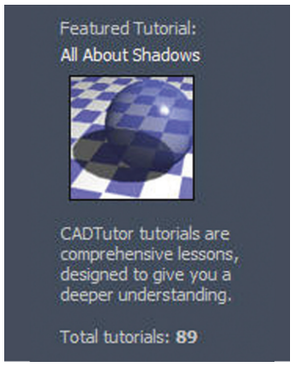

***Figure 1** - Typical Tutorial.*

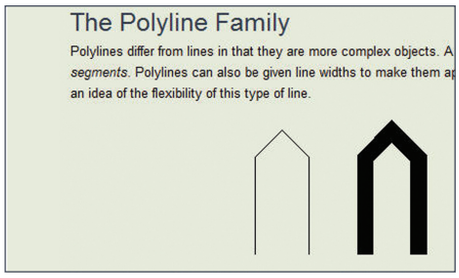

***Figure 2** - Autocad Command Tutorial where techniques are graded from the basics, beyond basics, to modelling and rendering.*

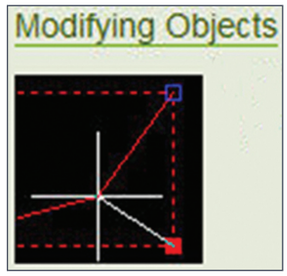

***Figure 3** - This tutorial runs through all the modify tools, demonstrating practical examples in each case.*

Claiming to be the 'Best free help for AutoCAD on the web' this site provides, for free, a variety (over 80) of graded tutorials, downloads, 3ds Max, Photoshop, a forum and other software.The CAD Tutor Download area provides free AutoCAD drawing files together with a selection of photo images. An AutoCAD 'FAQ' section together with a 'tip of the day' further enhances this useful website which provides easy access to a range of useful technology department resource material.

How much is too much sun?

Investigations using UV-sensitive yeasts

Over the last decade the incidence of skin cancer in Scotland (specifically malignant melanoma) has increased by a staggering 30% [1]. The increased occurrence of this type of cancer can be attributed mainly to the rise in the number of Scots taking holidays abroad each year. A significant factor, particularly amongst younger people, is the use of sun-beds to achieve that healthy glow [2]. It is therefore important to ensure that our young people are informed of the dangers of too much sun or the over-use of sun-beds. We describe a practical activity which can be used to underpin this message.

Background

When UV radiation hits living cells it may damage the DNA of the cells causing mutations. However, most cells can switch on repair mechanisms to deal with the mutations induced by UV radiation. Repeated damage to the DNA increases the chance of mutations being missed by these cellular repair systems. In humans this failure to repair may result in wrinkles, damage to the immune system and skin cancer.

DNA repair genes are found in normal baker's yeast (*Saccharomyces cerevisiae)* and have a similar function to those found in human cells. Some strains of yeast have mutations which prevent them from making certain repairs such that they then die when exposed to UV radiation. The commercial availability of UV-sensitive yeasts thus provides us with a reliable tool for use in the classroom to study the effects of this type of radiation on cells.

Preparing for the Activity

Prior to this investigation, Yeast Glucose Agar (YGA) plates need to be prepared. YGA is a nutrient-rich medium that provides everything yeast needs to grow. The number of plates required will depend upon how the experimental protocol is adopted.

A UV-sensitive strain of yeast is available from Blades Biological (www.blades-bio.co.uk/); tel: 01342 850242). Stock plates of the yeast should be prepared from the initial culture by streaking and incubating at room temperature for 4-5 days or in an incubator at 30°C for 2-3 days. Plates should be wrapped in aluminium foil to reduce exposure to light during this phase. Using aseptic technique, a single colony from a stock plate should be suspended in 10 cm^3 sterile water and this suspension used as the starting point for a serial dilution of the organisms [3]. It is important to ensure that the bottles are covered in aluminium foil to protect the yeast cells from light. Serial dilution is necessary to ensure an appropriate number of colonies for counting will be obtained on the final plates (Figure 1).

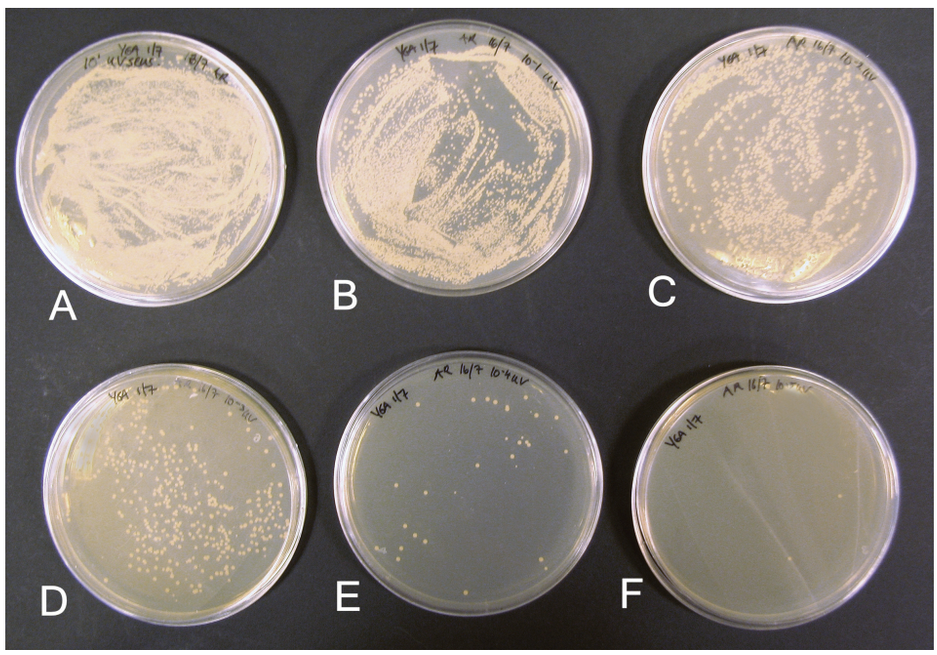

Figure 1 *- Serial dilutions of UV-sensitive yeasts showing the reduction in colony numbers. A = stock solution; B = 10^{-1} dilution; C = 10^{-2} dilution; D = 10^{-3} dilution; E = 10^{-4} dilution; F = 10^{-5} dilution.*

We found that a dilution of 10^{-4} provided a countable number of colonies. Pupils could carry out their own serial dilutions, particularly if they are using this technique for an AH Biology investigation.

The light source that we used initially was the sun. We found that on a bright, sunny day in the middle of summer, 15 minutes exposure time was enough to kill off most, if not all, of the mutant yeast cells. However, on cloudy or autumnal days the plates required 40-45 minutes exposure for cells to be substantially affected by UV. If the experiment is carried out in winter months it may be necessary to expose the yeast cells to a UV light source (we used a BDH lamp Ref. no. VL-315.BL, wavelength 365 nm). During all experiments, the lids were left on the Petri dishes since UV light (365 nm) is transmitted through plastic. Taking the lids off the dishes to expose the cells to UV is not recommended since we found that contamination of plates occurred when exposure times had to be longer.

Carrying out the Activity

Prior to, and after carrying out the activity students should wash their hands well with soap and water and clean their work areas thoroughly using 1% bleach or Virkon™ and should use aseptic technique throughout [4]. Groups of pupils could be provided with a bottle of a 10^{-4} dilution of yeast cells. Using a sterile disposable pipette, 0.25 cm^3 of the suspension is removed from the bottle, ensuring that the neck of the bottle is flamed before and after removal. The suspension is transferred to the YGA plate and spread across the agar using a disposable spreader (reusable glass spreaders must be dipped in alcohol and flamed before and after).

We would advise that each group spreads a minimum of four plates. Plate 1 is not exposed to light, remaining covered in foil, and acts as a control. Plates 2, 3 and 4 are replicates for a given exposure time[1].

The foil is removed and the plates are exposed to light for a given length of time, depending upon the lighting conditions. Different groups would expose their plates for different lengths of time. The plates should then be re-covered with foil and incubated at 30°C for 2-3 days, or at room temperature for 4-5 days, after which time the numbers of colonies in each plate can be counted and compared (Fig 2a and 2b).

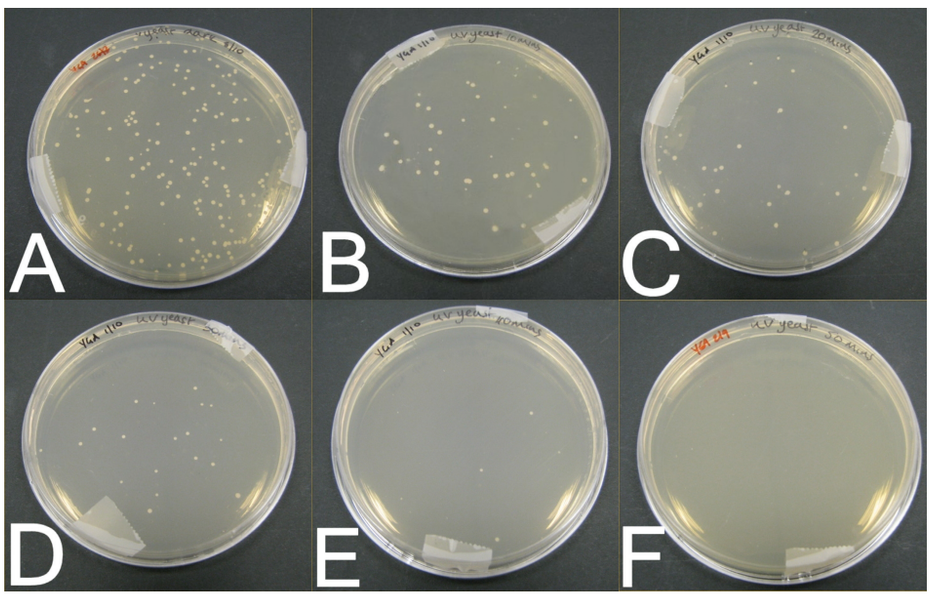

Figure 2a *– UV-sensitive yeast exposed to sunlight for different lengths of time (colony counts were made after 2 days incubation at 30°C). A decline in numbers is observed as exposure time increases. A = time zero; B = 10 min exposure; C = 20 min exposure; D = 30 min exposure; E = 40 min exposure; F = 50 min exposure.*

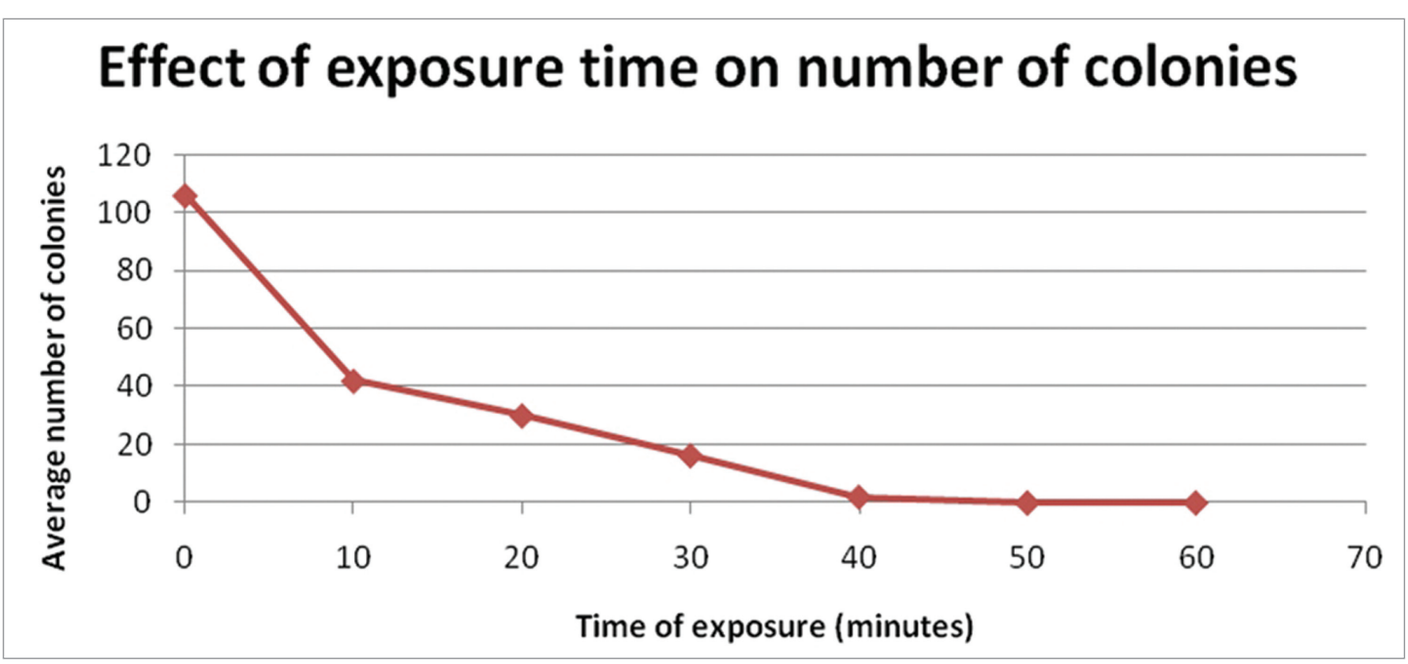

Figure 2b *– Graphical representation of the data in Figure 2a. Sunlight was used as the source of light. Qualitatively similar results were obtained using a UV lamp emitting at 365 nm.*

[1] An attempt was made to divide plates into four sections, using one as a control and the others as experimental sections. However, it was felt that this did not allow a fair comparison between sections as the yeast suspension did not always appear to be evenly spread.

How much is too much sun?

Applications

This technique can be used to investigate the effects of the following variables on the number of yeast colonies:

- Length of exposure to UV source
- Normal yeasts (e.g. baker's yeast) versus mutant strain
- Different Sun Protection Factors (SPF) of sunscreen (Figure 3), including lotions and oils with no SPF
- Different brands of sunscreen
- Do old bottles of sunscreen work as well as new ones?
- Different types and colours of fabrics
- Different sunglasses

It can be clearly seen from the results that as exposure time increases, the number of colonies growing after 2 days decreases substantially.

If sunscreens are to be applied, 0.2 g of sunscreen is sufficient to coat the surface of the lid. This can be spread out using a paper towel and removed once the plate has been exposed to the requisite amount of sunlight. It was found that, if left on for several days, the sunscreens clouded the lid and made observation of the colonies more difficult.

Preliminary studies looking at the effects of sunscreens containing different SPF indicate that the use of sunscreens increase the number of colonies growing after one hour exposure to UV light, but this effect depends on the SPF factor of the cream (Figure 3). Several trials have indicated that Factor 25 makes very little difference compared to the use of Factor 15. However, comparison with higher factors e.g. SPF 50 would be useful to investigate if this level of protection produces a substantial difference.

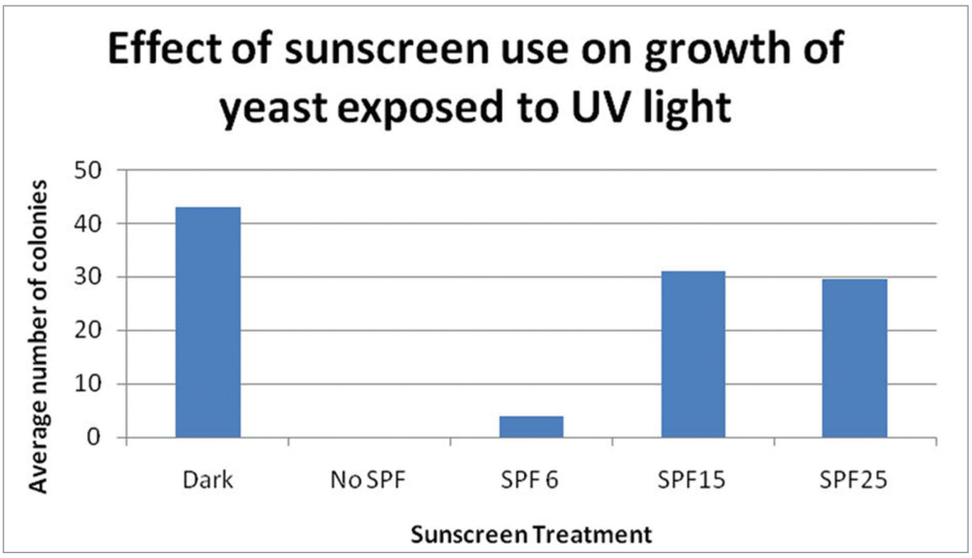

Figure 3 *– Plot showing the effect of sunscreens with different SPF values on the number of colonies (after 2 days incubation at 30°C) after exposure to UV light. Sunscreens were applied to the lids of the Petri dishes before irradiation. The control plate was not exposed to UV light.*

This technique lends itself extremely well to an AH Biology investigation or as part of a wider piece of work looking at the harmful effects of the sun and sun-beds. In terms of Curriculum for Excellence the activity might be used to support outcomes in Topical Science, encourage manipulative and investigative skills, and raise awareness about an important health issue.

References

1. http://isd.scot.nhs.uk/isd/1048.html (accessed 15th April 2009)
2. http://info.cancerresearchuk.org/news/archive/pressreleases/2006/may/151734 (accessed 15th April 2009)
3. http://www.sserc.org.uk/members/SafetyNet/Microbio2/Documents/Techniques%20Cards.pdf (accessed 15th April 2009)
4. http://www.sserc.org.uk/members/SafetyNet/Microbio2/AT/PrepSW.htm (accessed 15th April 2009)

Science CPD@SSERC

We have previously reported [1] on the work of the three-year project *Support for Science Education in Scotland through CPD* (known affectionately within SSERC as 'The Project'). Through this collaborative, Scottish Government funded project, SSERC and its partners offer experiential professional development opportunities to a range of groups who are key to providing a stimulating learning environment for school science. As we approach the end of the first year of the work of *The Project* it is worth taking stock of what we have achieved.

Primary and Secondary teachers: more than 150 teachers attended two-part '*Bridging the Gap*' courses, each lasting a total of five days. These courses provide resources and equipment to take back into school. Delegates move forward their own practice by carrying out a 'gap task' in the classroom between Parts 1 and 2 of the courses.

"This is a superb course full of excellent material with very professional and extremely likeable presenters".

Technicians: a range of units have been developed by the SSERC / STAG partnership and credit-rated and levelled by the SQA. Training courses which offer technicians the opportunity to gain these qualifications are being held by Local Authority Training Partnerships across the country. During the year over 150 technical staff have attended SSERC courses covering topics including Chemical Handling, Microbiology for Schools, Electrical Safety and PAT Testing, and Safe Use of Fixed Workshop Machinery.

Trainee teachers: In January 2009, one hundred and seventy student teachers from across Scotland came together to experience some high quality, experiential professional development for two days at the Scottish Universities Science School. The programme offered presentations (including one from Professor Stuart Monro, Scientific Director of *Our Dynamic Earth*), laboratory work suitable for early secondary students, together with sessions on formative assessment, discussion techniques, and services offered through SSERC.

"This course was absolutely excellent. I honestly could not fault it and I regard it as one of the most impressive and informative activities I have participated in with regard to teacher training."

Probationer teachers: To offer the 'C' in CPD, we invited twenty delegates who had attended the Scottish Universities Science School in 2008, to come together again during their first year of teaching. The formula was 'more of the same but different' and we provided sessions on co-operative learning as well as practical work and formative assessment activities that could be taken back into the classroom.

"This course was excellent – great activities I will actually use, superbly organised and amazing staff who are willing to answer any questions – very inspiring!"

The Scottish Science Education Conference (SSEC): Organised as a partnership by ASE Scotland and SSERC this conference was held at the Dunblane Hydro Hotel on 6th and 7th March 2009. Some 250 delegates attended what was generally accepted to be a highly successful event. Plans are already at an advanced stage for SSEC 2010 so watch this space!

Curriculum leaders: Twenty eight new or aspiring curriculum leaders participated in Part 1 of a five-day two-part course, '*Leading for Excellence in Science'*, held at Crieff Hydro in March 2009. The course provides opportunity to take on board new ideas and acquire and develop skills necessary for leadership and management of school science departments.

What next? Between now and the end of the 2008/2009 academic year we have a range of CPD courses (both residential and non-residential) including Summer Schools for secondary teachers of biology, chemistry and physics.

Further details of all our courses can be found at www.science3-18.org.

"The courses are very useful - every science teacher should go on one of these!"

For 2009-2010, we plan to build on the very successful programme of CPD with an increased variety of courses.

Registration and programme details will be posted at www.science3-18.org – why not visit the Professional Development part of the website on a regular basis?

References

SSERC Bulletin (2008) No. 226. or http://www.sserc.org.uk/members/SafetyNet/bulls/226/CPD_at_SSERC.htm

The Mystrica Colorimeter

Background

Colorimeters are desirable, occasionally essential, pieces of equipment for use in secondary chemistry and biology laboratory work. A major factor which limits the availability of colorimeters is cost. Within SSERC we routinely use WPA CO7500 colorimeters (see www.wpaltd.co.uk) – the current price for each unit is £355 (excl. VAT and postage). It would be rare to find institutions which are able to provide class sets of such equipment. In this report we explore the design, reliability and scope of a new colorimeter marketed by Mystrica (see www.Mystrica.com) – the current (March 14 2009) listed price being £76 (excl. VAT and postage).

Figures 1 & 2
The Mystrica colorimeter.

Operation

The Mystrica colorimeter (*MC*) uses light emitting diodes as light sources. Three diodes are available – blue (470 nm), green (535 nm) and red (630 nm). The beam from the diode passes through a conventional cuvette of 1 cm pathlength (10 such cuvettes are supplied with the colorimeter). Operation is simple – a calibration reading is taken followed by a reading of the sample. The colorimeter comes supplied with 4 batteries (AA, 1.5 V) or alternatively can be operated without batteries by connecting it to the USB port of a PC (Mac versions of the software are under development at the time of writing this report). When operating on battery power the unit automatically shuts down after a period of 6 s in order to prolong battery life. Whilst such a time interval is relatively short, the calibration data is retained when the machine is switched off and so a new calibration is not required between individual sample readings. Readout of data in both absorbance and percentage transmittance is possible. The estimated battery lifetime is 100 hr of continuous use or 60 000 readings.

The USB link allows data to be collected either as individual events or at intervals of 1 s. Data can be stored and analysed utilising free software which can be downloaded at www.Mystrica.com. Alternatively data can be imported into a range of different spreadsheet/data analysis packages (e.g. Microsoft Excel).

Test Samples

Neutral density filters

Utilising the green diode as the light source an empty cuvette was placed in the sample chamber and calibrated. Neutral density filters (available from Lee Filters - see www.leefilters.com) were used to test the response of the *MC*. Filters (each with an absorbance of 0.3 at the excitation wavelength) were placed in the cuvette and absorbance recorded.

The results from such experiments are shown in Figure 1. The slope of the plot shown in this figure is 0.29 (against a predicted value of 0.30).

Comparative experiments using the WPA CO7500 colorimeter using a 520 nm filter yielded a linear plot with a slope of 0.30 (data not shown).

Similarly impressive linear plots were obtained with the *MC* using blue (470 nm) and red (630 nm) diodes as the excitation source and neutral density filters as the absorbing sample.

Absorbance of Coloured Solutions (535 nm excitation)

Potassium manganate(VII)

The absorption spectrum of potassium manganate(VII) in water displays a

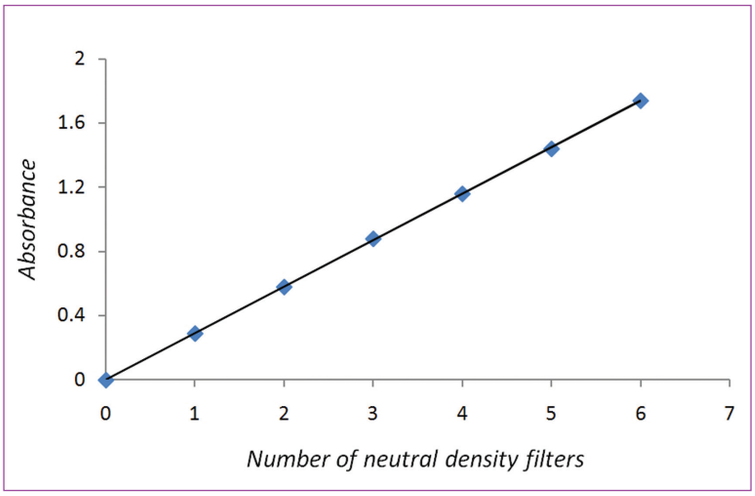

Figure 3 *- Absorbance, as measured using the Mystrica Colorimeter, as a function of the number of neutral density filters present. Each neutral density filter is rated by the manufacturer as having an absorbance of 0.3. Excitation wavelength was 535 nm.*

number of maxima in the visible region. At 535 nm the molar absorption coefficient of potassium manganate(VII) is *ca.* 2.0 x 10^2 m^2 mol^{-1} [Perkampus and Schmiele, 1967]. A stock solution (2 x 10^{-3} mol dm^{-3}) of potassium manganate(VII) was prepared in water. Dilutions of the stock were prepared and the absorbance of each measured using the green diode as the excitation source. The resulting data are shown in Figure 4. An entirely adequate standard curve could readily be generated from such data.

Rhodamine 6G

The absorption spectrum of rhodamine 6G in water shows a maximum in the green portion of the visible spectrum with a molar absorption coefficient at 535 nm of *ca.* 7.0 x 10^3 m^2 mol^{-1} [Johnson, 1995]. A range of rhodamine 6G solutions in water, in the range 0 – 2 x 10^{-5} mol dm^{-3}, were prepared and the absorbance of these solutions was measured using both the WPA colorimeter with a 520 nm filter and the *MC*. The results are show in Figure 5.

It should be recognised that the absolute values of absorbance in the two data sets in Figure 5 are not directly comparable since different wavelengths of observation are being used. However non-linearity is clearly observed in the case of data obtained using the MC.

On the basis of potassium manganate(VII) results (see Figure 4) one might have expected that the Mystrica colorimeter would also show a reasonably linear response when using rhodamine 6G solutions. The non-linearity shown is interesting and, at first glance one might argue, worrying.

The most logical explanation for the observed effect is that fluorescence from the sample (rhodamine dyes, in general, display fluorescence yields in excess of 50%) is being detected. In 'conventional' colorimeters and spectrophotometers, the detector collects light which has either passed through a filter or a monochromator and only light of those wavelengths being absorbed is detected (fluorescence being at longer wavelengths is minimised or excluded). A simple view of the design of the Mystrica colorimeter is shown in Figure 6. In the case of rhodamine 6G an alternative explanation may hold (Figure 7).

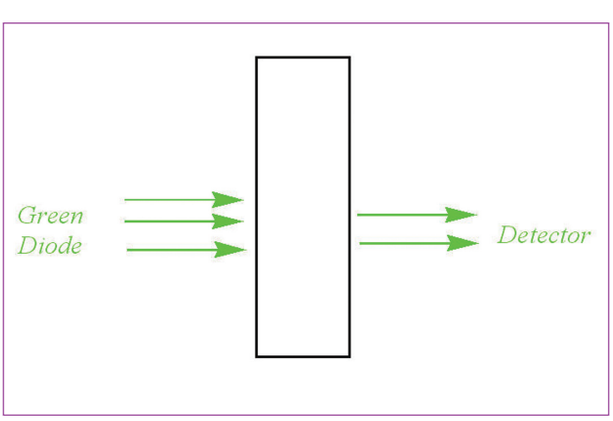

***Figure 6** - The detector collects all light. Light which is absorbed in (say) a potassium manganate(VII) solution reduces the amount falling on the detector and the change in intensity is converted into an absorbance reading.*

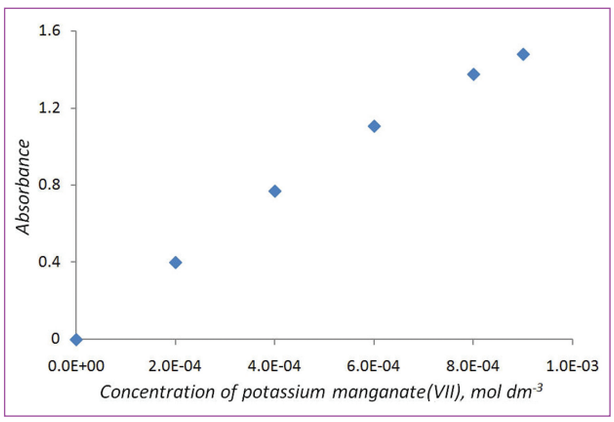

***Figure 4** - Absorbance, as measured using the Mystrica Colorimeter, as a function of the concentration of aqueous solutions of potassium manganate(VII). Excitation wavelength was 535 nm and pathlength was 1 cm.*

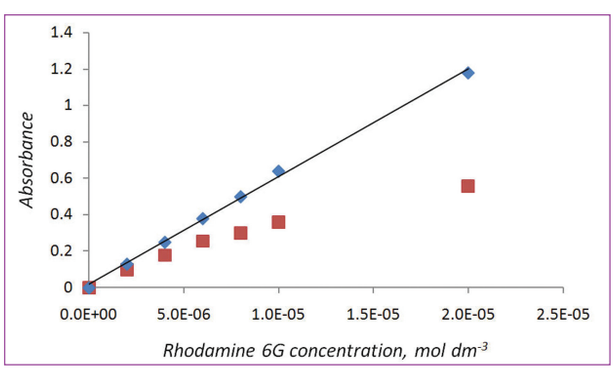

***Figure 5** - Absorbance as a function of the concentration of aqueous solutions of rhodamine 6G. Excitation was 535 nm and pathlength was 1 cm. The colorimeter used was either a CO7500 colorimeter using a 520 nm filter (◆) or the Mystrica Colorimeter (■).*

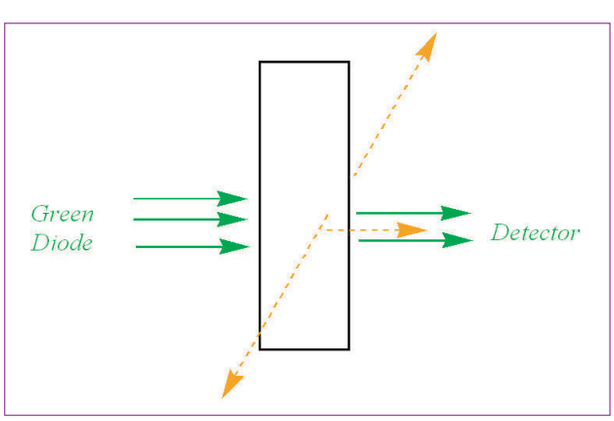

***Figure 7** - Here fluorescence is emitted in all directions and, since there are no filters in place, some of this may fall on the detector. Even though light has been absorbed in the solution the detector does not 'see' this by way of the full reduction in intensity which might be expected since some of the green light has been converted into orange light which the detector also collects. So the apparent absorbance in the cuvette is lower than the actual/true value.*

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Therefore, should the sample under investigation fluoresce with reasonable efficiency (no attempt has been made to determine the threshold above which fluorescence detection becomes a problem) then there is a chance that the *MC* will collect such fluorescence and give false readings. For most materials likely to be used in the school/college laboratory this will not be a major problem.

Absorbance of Coloured Solutions (630 nm excitation)

Methylene Blue

At 630nm the molar absorption coefficient of methylene blue is *ca.* 4.2 x 10^3 m^2 mol^{-1} [Prahl, 2008]. A stock solution of methylene blue was prepared at a concentration of 1 x 10^{-4} mol dm^{-3} in water. Dilutions of the stock were prepared and the absorbance measured using the *MC*; results are shown in Figure 8.

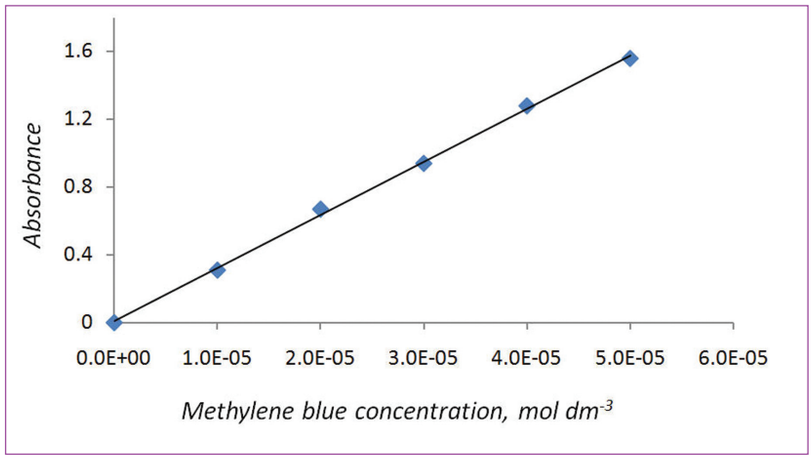

***Figure 8** - Absorbance, as measured using the Mystrica Colorimeter, as a function of the concentration of aqueous solutions of methylene blue. Pathlength was 1 cm.*

Absorbance of Coloured Solutions (470 nm excitation)

Potassium manganate (VII)

At 470 nm the molar absorption coefficient of potassium manganate (VII) is *ca.* 50 m^2 mol^{-1} [Perkampus and Schmiele, 1967]. A stock solution of potassium manganate (VII) was prepared at a concentration of 2 x 10^{-3} mol dm^{-3} in water. Dilutions of the stock were prepared and the absorbance of each measured using the green diode as the excitation source and the data are shown in Fig. 9.

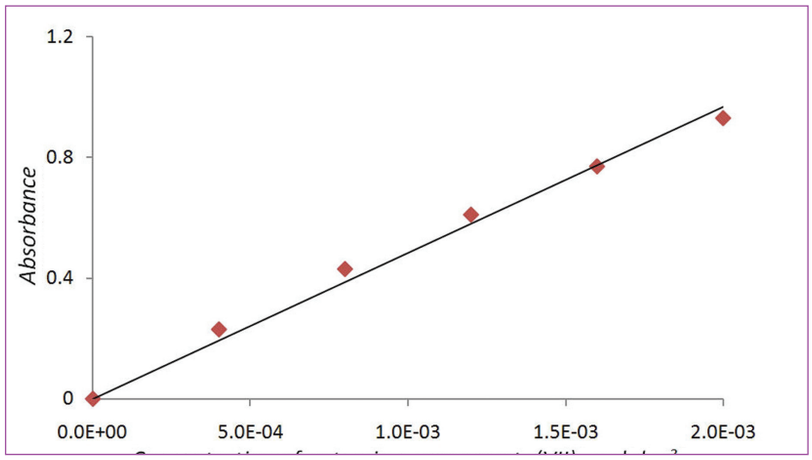

***Figure 9** - Absorbance, as measured using the Mystrica Colorimeter, as a function of the concentration of aqueous solutions of methylene blue. Pathlength was 1 cm.*

Summary and Conclusions

The Mystrica Colorimeter represents excellent value for money as a simple, robust and reliable colorimeter for use in schools/colleges.

In a subsequent issue of the *SSERC Bulletin* we will explore how the Mystrica Colorimeter can be used in kinetic studies in biology and chemistry.

References

Johnson, D.G. (1995) An investigation of excited state properties of some rhodamine dyes, PhD Thesis, University of Salford, p 134.

Perkampus, H-H. and Schmiele, C. (1967) in '*UV atlas of organic compounds*', figure K1/12, Plenum Press, New York.

Prahl, S. (2008) Optical absorption of methylene blue, http://omlc.ogi.edu/spectra/mb/index.html (accessed March 14th 2009).