NEWSLETTER

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Editor: Thomas P. Coohill, Depts. of Biology and Physics,
Western Kentucky University, Bowling Green, KY 42101 tel.: (502) 745-3697

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ASP - Newsletter

Smithsonian Fellowships

The Smithsonian Institution offers fellowships in residence to support independent research and study in fields which are actively pursued by the various bureaus of the Institution. Individuals are selected competitively and are appointed to work under the guidance of professional staff members and use the collections and the facilities of the Smithsonian. The Institution does not generally support work to be done in other institutions. It does not offer courses nor does it award degrees. The Smithsonian does not discriminate on grounds of race, color, sex, religion, national origin, age or condition of handicap of any applicant.

Six to twelve month pre- and postdoctoral fellowship appointments and ten-week graduate student appointments are awarded. Proposals for research in the following areas may be made:

- History of Science and Technology
- History of Design and Decorative Arts
- American Material and Folk Culture
- History of Music, Musical Instruments
- History of American and Oriental Art
- History of African Art and Culture
- American Social, Political and Military History
- Anthropology, Linguistics, Archaeology
- Evolutionary and Systematic Biology
- Radiation Biology
- Earth Sciences and Paleobiology
- Ecological, Behavioral, and Environmental Studies in Temperate and Tropical Zones
- Materials Analysis and Conservation of Museum Objects

An applicant must offer a specific and detailed research proposal and indicate clearly why the Smithsonian is an especially appropriate place to conduct the work proposed.

The primary objective of the fellowships is to further the research training of scholars and scientists in the early stages of their professional careers. Predoctoral fellowships are offered to students who have completed preliminary course work and examinations and are researching their dissertation. Postdoctoral fellowships are offered to investigators who have recently completed the doctoral degree. Generally awards are not made to applicants more than five years beyond the degree at the time the fellowship commences, although the five-year limitation may be waived upon demonstration that a fellowship appointment would clearly be research training. Candidates without the Ph.D. but with the equivalent in experience, accomplishment, and training may be considered. Graduate student applicants must be enrolled in a program of graduate study and have completed a minimum of one academic semester at the time the appointment begins.

Stipends supporting the awards are: $17,500 per year plus allowances for postdoctoral fellows: $10,500 per year plus allowances for predoctoral fellows; and $2,000 for graduate students for the ten-week period of appointment. Stipends for pre- and postdoctoral awards are prorated on a monthly basis for periods of less than one year.

Individuals interested in astrophysics or geophysical research should write to:
Smithsonian Astrophysical Observatory
60 Garden Street
Cambridge, MA 02128

For applications and more information about all Smithsonian fellowships, including the publication, Smithsonian Opportunities for Research and Study, which describes the Institution's bureaus and facilities and lists the professional staff and their research interests, please write to the Office of Fellowships and Grants at the Smithsonian Institution, L'Enfant Plaza, Suite 3300, Washington, D.C. 20560.

APPLICATION DEADLINE IS JANUARY 15TH EACH YEAR

UV Dosimetry: Efficacy Units

By: Ronald E. Davies
Temple University

A previous communication (February, 1983 Newsletter) considered some problems in describing UV exposure in physical units. This section will discuss additional difficulties which arise when the effects of the exposure are to be considered.

If a source of radiation is monochromatic and constant in direction, most physical descriptions of the delivery of energy to a target are interconvertible (i.e. photon count, joules, calories etc. are reproducibly related). Within moderate ranges of intensity the transfer functions relating input to biological or chemical consequences are often constant (i.e. the response exhibits "time-dose reciprocity", and the magnitude of response is a function of the time-integrated input). In such circumstances it is convenient and acceptable to describe the dose (or fluence) producing a specific consequence in the physical units of input, a "dose" of so many joules, photons etc. (per unit of target area). The same dimensional units will be equally applicable if the irradiating wavelength is changed, but since the transfer function will often be different the number of units required to produce the same effect may change.

To anyone familiar with the concept of action spectrum, the above statements are obvious. The transfer function referred to is the action spectrum, and the relative effectiveness of the different wavelengths is "accounted for" by applying the appropriate spectral weighting function to the contribution of each wavelength. In this way the capacity of even polychromatic sources to produce a given response can be expressed in the physical input units, and a deceptively simple description results. The difficulty is that the description is presented in dimensions of measurable physical units, whereas in fact effectiveness cannot be measured by a direct physical process.

Again, this is obvious. No photobiologist would interpret the statement that "the minimal erythema dose for untanned human skin is 200 J/m^2" as indicating that 200 joules of gross energy from any radiation source, delivered to a square meter of skin, would produce erythema. A cautious speaker would add the restriction "200 J/m^2 of 297 nm-equivalent energy," and would understand this to mean that 200 J/m^2 of monochromatic 297 nm energy, or the amount of any other wavelength or group of wavelengths equivalent in effectiveness, would produce erythema. The second half of this statement, however, is a tautology; the number 200 is not related in any simple way to the amount of gross energy which must be delivered. What is needed is the spectral distribution of the source and the spectral sensitivity function of the response (and fervent belief in both time-dose reciprocity and wavelength additivity). Together these will permit us to calculate the amount of gross energy of that particular spectral distribution required to produce the response; with that information in hand, direct measurement of input intensity will permit us to estimate dose delivery time, or vice versa.

It is common practice to describe energy in the long-wavelength UVA (320 nm) in "unweighted" physical units because relevant action spectra are not well established. This practice causes relatively little confusion provided that all related studies are conducted with identical source spectra, but the statement that a given effect was produced by so many $Joules/m^2$ of UVA is unlikely to be equally true for a Wood's light, a fluorescent black light, and a Xenon arc. As one consequence, safety standards based on such unweighted physical units have little objective basis as predictors of potential damage.

With shorter wavelengths (320 nm) the problem is more acute; a number of photobiologic processes of practical significance are known to have complex action spectra in this region, with efficacy of different wavelengths differing by orders of magnitude. It is not uncommon to find incident energy of this spectral type described in physical units (e.g. $Joules/m^2$) in a context which suggests that what was measured (or at least what was intended) was a description of gross energy in a restricted spectral region. Only two radiation sources, the FS fluorescent sunlamp and the essentially monochromatic low-pressure mercury arc or "germicidal" lamp (254 nm) can be considered to represent "standard" emission spectra in this region; they are distinctly dissimilar and unrepresentative of any other source of short-wavelength radiation. Xenon arcs and tungsten lamps, as generally used, are attenuated by various lenses, filters and mirrors; even when filtration is specified by type and (nominal) thickness, such sources vary spectrally by amounts which make gross energy measures of limited value. In this region, even more than in the longer-wavelength UV, unweighted physical units of energy or intensity provide little basis for prediction of efficacy. Thus even though it is possible, for a specific source and a specific detector, to obtain a scaling factor to convert instrument response to energy units, the results will only have predictive utility for that source. Since all spectral distribution information is lost in the integral detector reading such values alone will not provide useful data even if the action spectrum of the biological (or chemical) response is known. What is called for is quantitative and qualitative information on source spectral distribution, and this is often not provided.

This problem can be neatly bypassed if the detector response characteristic is identical to the target action spectrum; in such a case the detector directly weights the input spectral components in proportion to their efficacy, and the detector response to <u>any</u> input is predictive of the desired target response. This is the operating principle of the metering system devised by Robertson and developed by Berger to estimate the sunburning potential of solar-like sources; the response spectrum of the meter mimics that of human erythema over a range of wavelengths (290 nm) which represents the maximum effectiveness of such sources. Properly used, this is a practical and reliable approach for generating useful numeric descriptions of energy delivery to a biological target. Even in this case, however, misleading information can be obtained. The spectral match to erythema efficacy is good but not perfect; the meter overestimates (relatively) the effectiveness of longer wavelengths. In its intended application, measurement of effective solar irradiation, this error term is relatively small and predictable, permitting the use of appropriate corrections. Under other circumstances, however, the error may be quite large: the sunburning efficacy of fluorescent sunlamps is underestimated by a factor of at least 3 relative to that of thermal (solar) sources. Again appropriate scalling can be applied, but the point is that the predictive meaning of a meter response unit is not independent of the source if the detector response characteristic is not identical to that of the intended target. The rather widespread use of this metering system to measure input to systems with unknown response spectra is another troublesome example of measurement problems: in such cases the basic design principle, simulating the target response, is being ingnored. In partial justification of such measurements, the system provides arbitrarily weighted input information which emphasizes the shorter (often most potent) spectral components.

It is important to note that the measurement units of the Robertson-Berger Sunburning Ultraviolet Meter are <u>not</u> translated into physical units, but are expressed in arbitrarily defined Sunburn Units. This has the virute of implying directly that measurement is in terms of estimated efficacy, and thus avoids the ambiguity of unqualified physical units. (It also emphasizes the uncertainty of applying such units in the evaluation of systems other than skin). The approach is analogous to that of instrumental measures of illumination intensity except that the illuminant question is so well-recognized that a standard weighting function (the spectral luminous efficacy curve) has been defined which approximates the human visual response spectrum. Measurement systems with response spectra which approximate this weighting function thus read directly in units (e.g. lumens/sq. meter) which estimate biological efficacy and which are precisely analogous to the rate component of Sunburn Units (e.g. Sunburn units per hour) with a different weighting function. In the case of illuminants there is no attempt to translate response-based units into a physical energy equivalent: it is generally understood that units such as watts, when applied to electrically-excited sources, refer to input energy rather than emitted energy, and for other sources, such as gasoline lanterns, such units are not used at all (physical energy units do appear in the <u>luminous</u> <u>efficacy</u> of radiation, expressed in lumens per watt). It would be possible but meaningless for a lighting engineer to specify illuminance in watts per square meter. It is equally meaningless to specify UV irradiance in watts per square meter if efficacy for a specific <u>process</u> is implied, but it is not always recognized as meaningless. The type of translation described previously, e.g. watts or joules of 297 nm - equivalent radiation, is also unsatisfactory, not only because the appropriate weighting function is not a matter of general agreement, but because it retains a physical term (watts) in an inappropriate context. Even a defined weighting, of course, is only as appropriate as it is useful: the Sunburn Unit is likely to be a better predictor of bacterial killing than is the time-integral of lumens, only because it measures closer to the relevant spectral region.

Let us consider a practical example of the problem of applying dosimetric information. Assume that a certain photobiologic effect has been reported following 20 weeks of daily exposure of the target to 500 J/m^2 from a "a UV source". We wish to reproduce this effect using a xenon arc source. How much radiation must we deliver? Since a "UV source" was specified we may assume that the measurement refers to UVR, but what does the number mean?

If we know something about the target, we may be able to make some limiting estimates. For example, if the target is non-hairy mouse skin we can assume that the energy delivered was not "erythema equivalent energy" relative to 297 nm, since such a chronic dose (2.5 mimimal erythema doses per day) would seriously injure or destroy the animals. On the other hand if the dose described was unweighted long-wave UV (320) it is a factor of 500 - 1000 below that which might be expected to produce an acute response, and therefore seems unlikely to produce subchronic effects. This latter conclusion might be altered if most of the energy was concentrated near 320 nm, which may be more biologically effective than longer radiation, but practical sources with such a distribution do not exist. It seems likely, then, that the source in question contained shorter-wavelength radiation (possibly a fluorescent sunlamp or a medium-pressure mercury arc), and that the energy units may have represented either unweighted UV energy or energy weighted by some function which did not emphasize erythomegenic efficacy.

Turning to the xenon arc source, we can alter its erythemogenic potential by orders of magnitude, with little change in total UV intensity, by the use of short-wavelength cutoff filters. Even with an unfiltered xenon arc we would not expect acute effects from 500 J/m^2 of total UV energy; if we removed 20% of the total by cutting off the short-wavelength end the source would almost certainly be benign. We expect, therefore, to need to deliver total energy greater than 500 J/m^2, but unless we have some idea of the effectiveness of the component wavelengths, we have no meaningful way of estimating this dose. Thus, even though we have inferred much more than was stated we still have no basis for evaluating the reported dose in terms relevant to our proposed source.

If it is clearly stated that the source used was a fluorescent sunlamp, and that the reported energy represented unweighted integral energy (measured with a flat-response thermopile or derived from a knowledge of the response characteristic of the detector), we can calculate (from a knowledge of the spectral distribution of this source type) the input dose of each component wavelength. This will permit us to estimate energy requirements for our source if we can apply appropriate weighting functions to the components of <u>each</u> source. The effective delivered dose (product of incident dose and relative effectiveness) of each component wavelength must be integrated for all wavelengths, for the reference source; the corresponding intensity calculation must be made for the intended source; the ratio of the two integrals will be the time term for the intended exposure.

If the response of interest is believed to have the same action spectrum as an acute response such as erythema production, a possible procedure is to perform an appropriate biological assay of the two sources to compare their potency. Even simpler, in this case, is the possibility of measuring weighted intensity instrumentally, using the sunburning ultraviolet meter. It was pointed out previously, however, that the meter overestimates the efficacy of longer wavelengths. If the reference source was a fluorescent sunlamp, allowance can be made using the fact that the meter underestimates the efficacy of this source, relative to a particular type of filtered xenon arc, by a factor of three or four. Thus the required dose (Sunburn units) from the specified xenon source would be three to four times the required dose (in Sunburn units) from the fluorescent sunlamp. Similar cross-calibrations could be made with other sources. What must be recognized, however, is that any such calibration will only relate two specific sources: for generalized translation the individual emission spectra plus the relevant action spectrum are required.

Any clear physical description of input radiation, if properly defined, may be valuable to the extent that component information (spectral distribution) is known or can be recovered. Description of <u>effective</u> input energy such terms, however, is of limited value unless the relevant parameters for both source <u>and</u> response can be specified. There are few circulstances where physical units alone can provide a useful description of the efficacy of UV radiation.

<u>Ed</u>: Please direct any comments directly to Dr. Davies at Temple University in Philadelphia.

POSTDOCTORAL FELLOWSHIP. A position will shortly be available for a non-US citizen with not more than 1 year of postdoctoral experience to study the spectroscopic properties of skin photosensitizing chemicals. Applicants should have an interest in the application of ESR spectroscopy to the detection of photoinduced free radicals. Initial appointment is for one year at a salary of $16,000-17,000 per annum. Candidates should send a curriculum vitae and three letters of recommendation to Dr. Colin F. Chignell, Laboratory of Molecular Biophysics, National Institute of Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, N.C. 27709 USA.

COLOR SYMPOSIUM INAUGURATES RIT MUNSELL COLOR LAB

Frontiers in Color Science, a two-day symposium on color science, will inaugurate the Munsell Color Science Laboratory at Rochester (N.Y.) Institute of Technology (RIT) February 16 and 17, 1984.

Organized by Dr. Franc Grum, RIT's Richard S. Hunter Professor in Color Science, Appearance and Technology, the program will include presentations by 11 internationally-known authorities in color science.

The Richard S. Hunter Professorship in Color Science, Appearance and Technology, at RIT was established in October 1982 through an endowment by Mr. and Mrs. Richard S. Hunter of Reston, Va. The endowment honors Hunter, founder and chairman of the Board of Hunter Associates Laboratory, Inc., manufacturers of instruments for the measurement of color, gloss and other attributes of color.

W. David Wright, Great Britain, will speak on the history of color measurement; Gunter Wyszecki, Ottawa, on the development of CIE standards and their limitations; Robert M. Boyton, San Diego, on a system of photometry and colorimetry based on cone excitations, and Peter K. Kaiser, York, Canada, on photometry and the human observer.

Also, Fred W. Billmeyer Jr., Rensselaer, N.Y., will talk on industrial applications of color sciences; Grum, on fluorescence and its measurement; David MacAdam, Rochester, on color order systems; Milton Pearson, RIT, on color reproduction; Gunnar Tonnquist, Stockholm, Sweden, on applications of color order systems, and Robert W.G. Hunt, Great Britain, on color appearance in color reproductions.

C. James Bartleson of Eastman Kodak Company and Richard S. Hunter of Hunter Associates Laboratory will speak during inauguration ceremonies for the Munsell Color Science Laboratory. The Munsell Color Science Laboratory at RIT was established when the Board of Directors of the Munsell Foundation voted to dissolve the foundation and to turn its assets to the creation and maintenance of such a laboratory at RIT. This transfer of assets is the first time a foundation has voted to dissolve itself and to donate assets to an institution of higher education.

Ceremonies will be followed by a reception and tour of the newly created facility.

All presentations will take place in the second floor auditorium of RIT's George Eastman Memorial Building. Dedication ceremonies for the Munsell Color Science Laboratory will take place in the Frank E. Gannett Memorial Building at RIT.

Registration fee for the symposium is $100 and attendance will be limited to 100 participants. Accomodations will be arranged at the Rochester Hilton on the RIT campus.

There will be no written proceedings published of the symposium.

For further information, please contact: Dr. Franc Grum, School of Photographic Arts and Sciences, Rochester Institute of Technology, Post Office Box 9887, Rochester, NY 14623, (716) 475-2230.

NOTE: The January Newsletter will contain a complete meetings calendar for 1984.

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McLean, Virginia 22101