

SCOTOBIOLOGY

THE BIOLOGY OF DARKNESS

The Science of Dark-Dependent Biological Systems

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Introduction

The purpose of this paper is to outline the need for indepth research in scotobiology. A description of scotobiology is followed by discussions of the areas of science that constitute Scotobiology, and some details of the university and government laboratory and field research that is needed to improve our knowledge-base in this important subject. Finally, some suggestions are included for sources of funding that may assist research scientists to fund their own laboratories and to help support students or technicians in scotobiological research. This is an exciting opportunity for a university to take the lead in this new field of science.

Background/Definition

The science of Scotobiology – the biological science of darkness – was developed at the International Symposium entitled “Ecology of the Night”: Darkness as a Biological Imperative, held at Muskoka, Canada in September 2003. Scotobiology is a clearly defined new field of science that covers all biological systems that operate in the night, and which require and depend upon the absence of light to function normally. It is related to photobiology (the biology of systems that require or depend upon light) in that the light receptors are probably related. However, it is not simply a negative aspect of photobiology, but specifically the biology of systems that require darkness. The concept was developed to cover the wide range of subjects presented at the Symposium that although from many scientific disciplines, clearly had a single focus: the biological and sociological effects of anthropogenic light pollution of the night.

Scientific Scope

The Science of Scotobiology covers many areas of research in which a variety of papers and reports have been published:

- Animals, birds, and insects - particularly their behaviour: feeding, social, breeding, migratory behaviour, attraction to light.
- Plants - critical aspects, particularly the timing, of their development, flowering, onset of dormancy, etc.
- Human health – the correct functioning of the immune system; disease, cancer, sleep disorders, etc.
- Sociological, anthropological and cultural aspects of light pollution – including astronomy, the relationship of native peoples to the night, the fact that whole gen-

erations of people grow up who seldom see the stars on a dark night, or who have never seen the Milky Way in all its magnificence.

The Need for Further Research in Scotobiology

In general, many areas of biology fall within the description of scotobiology. These include aspects of the physiology and biochemistry of animals and plants, human biology (e.g. endocrinology, immunology, sleep disorders, etc.) and the underlying mechanisms of animal and plant behaviour. A more detailed (but by no means exhaustive) list of studies already published can be accessed on Internet sources. Particular reference can be made to the “proceedings” of the “Ecology of the Night” symposium held in Muskoka in 2003 which follows. Further scotobiological research is needed in all the areas listed below:

- Human health – particularly as affected by the disruption of the normal 24-hour cycle of light and darkness by night-time light, including effects on the diurnal operation of the immune system, the increased incidence of illness, particularly of cancer, and other physical and psychological effects of night-time light pollution, including mental health and stability.
- Animal and insect behaviour – including feeding, breeding and social behaviour and, particularly in the case of birds and insects, their attraction to light and the disorientation of their normal behaviour by bright lights.
- Plant reactions to light pollution. There is already a large amount of literature on the control of plant behaviour, especially flowering and the onset of dormancy, by their measurement of night length, and the disruption of this behaviour by illumination at night. However, more research, particularly field analysis, is needed on the specific effects of wavelength and intensity of light pollution.
- Human sociology: little is known yet about the effects of light pollution on the mental health of humans and societies of various racial and cultural backgrounds, particularly native peoples. This aspect of scotobiology needs further research to determine if there are problems, as has been suggested, and their scope.

There are several general themes that permeate many or all of the research areas noted above. These include the physiological and biochemical mechanisms that mediate the light responses in plants and animals that affect the normal operation of dark-requiring behaviours, the wavelength and intensity of light pollution affecting specific behavioural characteristics of animals (especially birds and insects) as well as plants, and the genetic basis of transduction systems that mediate the interference by light of dark-requiring processes. Research on these underlying phenomena is urgently required for a clear understanding of the basis of these scotobiological systems.

Products of such research will lead to techniques for determining the safe limits of light pollution, in terms of its intensity, duration, timing, wavelength, etc. Only with such well-founded scientific information will it be possible to establish and enforce effective control measures on light pollution.



Figure 1. Image of North America at night showing the extent of light pollution. The amount of darkness in the boreal forest region that should be protected is clearly visible (outlined in red). Image source: NASA. Goddard Institute for Space Studies. Satellite Images of World Night Lights in Global Warming Research.

Future Funding for Scotobiological Research

Scotobiological phenomena are important for human society for several reasons, all of which relate to their monetary value for society. Their importance for human health and social well-being is evident, and the possibility of decreasing health problems and increasing work-productivity are clearly valuable. In addition, the human ecology of the dark (exemplified by the institution of “Dark Sky Reserves”) is becoming of greater interest to government agencies, which are increasing the funding of such enterprises. The importance of decreasing or eliminating, so far as possible, the ecological damage caused by light pollution on animal, bird, insect and plant associations is also evident, and the present focus on interest in ecological concerns indicates that scotobiological research is already an important area of ecology that will demand increasing support. Furthermore, many of the species affected by light pollution are of considerable economic value, either as aesthetic objects or because of human activities (farming, hunting, etc.) that may depend upon them. Finally, there are secondary social costs that may be substantially reduced as result of scotobiological research. These include the saving of very large sums of money for energy resulting from the reduction of light pollution, the possibility of saving energy by using ecologically sound lighting for towers, buildings, etc. that need to be illuminated for safety reasons, and the reduction of health and industrial operating costs through increased understanding of scotobiological phenomena.

All these points suggest avenues for attracting research funds. It has been suggested that parks & reserves agencies should consider such funding for students doing research

on scotobiological problems that relate to the ecology of parks. Government funding agencies will respond to well-reasoned applications for research funds for programs that not only increase knowledge, but also have important industrial or sociological consequences. Industrial funding may also be available for projects relating to human health and productivity. Various non-governmental agencies dealing with ecological reserves might well be approached, as well as astronomical organizations. Finally, there is great interest in light pollution abatement in several European countries, particularly Czechoslovakia and Sweden, but also including the governing body of the European Union. The possibility for developing financial assistance for specific projects that would satisfy this interest would be well worth following up.

Finally, scientific organizations and funding agencies are aware that major undertakings for social changes, such as reducing light pollution, must be supported by science if they are to be successful. This may be a telling point for university and government laboratories wishing to develop funding for research on phenomena relating to the dark – for scotobiology.