## 2.0 Continuous Adjustments of the Visual System

### 2.1 Adaptation

To cope with the wide range of luminances to which it might be exposed, from a very dark night (10–6 cd/m$^2$ means theoretically much less than 0.1 lux*) to a sunlit beach (106 cd/m$^2$ means theoretically more than 100,000 lux*), the visual system changes its sensitivity through a process called adaptation. Adaptation is a continuous process involving three distinct changes.

### 2.1.1 Change in Pupil Size

The iris constricts and dilates in response to increased and decreased levels of retinal illumination. The maximum change in retinal illumination that can occur through pupil changes is 16 to 1. As the visual system can operate over a range of about 1,000,000,000,000 to 1, this indicates that the pupil plays only a minor role in the adaptation of the visual system.

### 2.1.2 Neural Adaptation

This is a fast (less than 200 ms) change in sensitivity produced in the retina. Neural processes account for virtually all the transitory changes in sensitivity of the eye at luminance values commonly encountered in electrically lighted environments, i.e. below luminances of about 600 cd/m2. The facts that neural adaptation is fast, is operative at moderate light levels, and is effective over a luminance range with a maximum to minimum ratio of 1000:1 explain why it is possible to look around most lit interiors without being conscious of being misadapted.

### 2.1.3 Photochemical Adaptation

The sensitivity of the eye to light is largely a function of the percentage of unbleached pigment in each photoreceptor. Under conditions of steady retinal illumination, the concentration of photopigment produced by the competing processes of bleaching and regeneration is in equilibrium. When the retinal irradiance is changed, pigment is bleached and regenerated so as to re-establish equilibrium. Because the time required to accomplish the photochemical reactions is of the order of minutes, changes in the sensitivity can lag behind the irradiance changes. The cone photoreceptors adapt much more rapidly than do the rod photoreceptors. Exactly how long it takes to adapt to a change in retinal illumination depends on the magnitude of the change, the extent to which it involves different photoreceptors and the direction of the change. For changes in retinal illumination of about 2–3 log units, neural adaptation is sufficient so adaptation should be complete in less than a second. For larger changes photochemical adaptation is necessary. If the change in retinal illumination lies completely within the range of operation of the cone photoreceptors, a few minutes will be sufficient for adaptation to occur. If the change in retinal illumination covers from cone photoreceptor operation to rod photoreceptor



** Conversion between cd/m$^2$ and Lux is indicative for understanding of the above Figures and based on typical experienced situations.*