22 Shining light on membranes

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There is a crack in everything, that's how the light gets in.
Leonard Cohen

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22.1 MEMBRANES AND LIGHT

The optical absorption spectrum of lipids or of lipid membranes does not display any peculiar feature in the visible wavelength range, from 400 to 700 nm. Indeed, the notable peaks of the absorption spectrum of a typical lipid are either in the UV-region, where double bonds absorb in the UVC region[1] around 200 nm, or in the near infrared region where the motion of the C-H bonds gives rise to several strong absorption peaks above 900 nm (Kuksis, 2012). Lipid membrane systems in general and giant unilamellar vesicles (GUVs) in particular can, therefore, be easily studied by techniques employing visible light, such as light microscopy: A GUV can be observed under a light microscope for many hours without being destroyed, transformed or even without suffering any visible degradation. Given such premises, one might wonder why a chapter about the interactions between light and lipid membranes is at all needed in this book … that is, until actual experiments would be performed under a microscope with realistic GUV systems. Phospholipids, cholesterol, proteins and other membrane-forming molecules that are fluorescently labeled—see book Appendix I—for visualization, solutions with fluorophores added for measuring permeability and other properties, biomimetic constructs, including light-sensitive proteins embedded or interacting with the bilayer … arguably most practical GUV systems strongly absorb light and bear thus the potential of inducing membrane transformations when exposed to visible light, by mechanisms that we discuss in this chapter. In the simplest cases, the membrane does not suffer any alterations from the illumination, yet it is still crucial as a support for the photoactivity of the hosted protein; we will see as an example in the next section how GUVs are essential platforms for understanding the photoreceptor activity of bacteriorhodopsin (BR). In most cases, however, the light activity of the hosted molecules induces a deep transformation of the membrane. We will refer to alterations where the lipid chemical structure in not modified, as physical transformations of the membrane. Section 22.3 describes two typical cases of such transformations where light-induced conformational changes of molecules embedded in the bilayer lead to pore formation or to complete destruction of the GUVs. The most dramatic perturbations induced by light correspond to chemical transformations of the lipids themselves, either (i) by a direct reaction with the photosensitizer (PhS)—a photosensitive molecule that becomes reactive by absorption of a photon—or (ii) indirectly by reactions with species activated by the PhS—for instance, with singlet oxygen ($^1O_2$). These aspects, discussed in Section 22.4, are important for many metabolic mechanisms. Indeed, lipid chemical transformations

[1] UVA: 315–400 nm; UVB: 280–315 nm; UVC: 100–280 nm.