MECHANISMS OF INDUCTION OF DNA DAMAGE BY VISIBLE LIGHT

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It is generally believed that visible light, at the intensity and energy doses encountered in everyday life, and in optical microscopy, exerts no direct detectable influence on DNA of human cells. Any effects observed on subcellular, cellular and tissue level are typically attributed to direct absorption by DNA of UV photons, and ensuing reactions leading to modification of nitrogen bases. No direct influence of visible light on DNA in nuclei of live cells is anticipated since DNA is believed not to absorb in the visible range of wavelengths.

In contrast to this generally held view, our research has demonstrated that visible light of moderate intensities and doses (mW, μJ), such as used routinely in fluorescence confocal microscopy, strongly induces typical DNA damage response (DDR), including phosphorylation of histone H2AX, and recruitment of various repair factors involved in repair of single- and double-strand breaks (Solarczyk et al. DNA Repair, 2012). Interestingly, no DNA oxidative damage induced by visible light (in the absence of fluorescent probes and exogenous photoreactive compounds) was detected.

DNA breaks induced by visible light were studied using spectrophotometry, spectro-fluorimetry, mass spectrometry and fluorescence confocal microscopy. A new sensitive DNA break detection technique STRIDE, which is based on chemical detection of individual DNA ends, demonstrated that visible light (400-600) nm can indeed induce single- and double-strand DNA breaks. Preliminary data demonstrated that the efficiency of this process depends on the wavelength of light, i.e. on the energy of a photon, and does not require molecular oxygen.

Mass spectrometry and fluorimetry data showed that various photoreactive molecules can induce chemical changes in oligonucleotides in solution upon illumination with blue light. Heme and riboflavin in solution were effective in inducing photosensitized damage, but heme embedded within cytochrome c did not cause any changes in the structure of oligonucleotides. These data suggest that photoreactive molecule excited by visible light most likely reacts with DNA, or induces reaction with DNA, upon direct contact with a polymer.

Fluorescence confocal and super-resolution imaging, mass spectrometry and fluorimetry hint towards two potential mechanisms – direct absorption of photons leading to breakage of phosphodiester bond, and photoinduced reactions between DNA-bound proteins and DNA bases, leading to protein-DNA crosslinks. In both cases typical as well as nontypical (not 3'OH ends) are likely induced.