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Retinal oxygen distribution and the role of neuroglobin. (English) Zbl 1343.92114

J. Math. Biol. 73, No. 1, 1-38 (2016).

Summary: The retina is the tissue layer at the back of the eye that is responsible for light detection. Whilst equipped with a rich supply of oxygen, it has one of the highest oxygen demands of any tissue in the body and, as such, supply and demand are finely balanced. It has been suggested that the protein neuroglobin (Ngb), which is found in high concentrations within the retina, may help to maintain an adequate supply of oxygen via the processes of transport and storage. We construct mathematical models, formulated as systems of reaction-diffusion equations in one-dimension, to test this hypothesis. Numerical simulations show that Ngb may play an important role in oxygen transport, but not in storage. Our models predict that the retina is most susceptible to hypoxia in the regions of the photoreceptor inner segment and inner plexiform layers, where Ngb has the potential to prevent hypoxia and increase oxygen uptake by 30–40%. Analysis of a simplified model confirms the utility of Ngb in transport and shows that its oxygen affinity (P_{50} value) is near optimal for this process. Lastly, asymptotic analysis enables us to identify conditions under which the piecewise linear and quadratic approximations to the retinal oxygen profile, used in the literature, are valid.

MSC:

92C35 Physiological flow
92C30 Physiology (general)
35K57 Reaction-diffusion equations

Keywords:

asymptotics; facilitated diffusion; hypoxia; oxygen transport; reaction-diffusion equations

Full Text: DOI

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