The Role of Vitamin A in Preventing Night Blindness and Other Severe Ocular Disorders

Arundeep Kaur and Marc Nahmani

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INTRODUCTION

❖ Vitamin A is an important micronutrient involved in light perception. Deficiencies in vitamin A impact rod photoreceptors located within the retina, which rely on components derived from vitamin A for visibility in dim lighting, leading to nyctalopia[33,37,48,52].

❖ Nyctalopia, or night blindness, is a condition where scotopic vision deteriorates overtime. While the causes of nyctalopia remain debated within the literature, certain factors have been proposed as early indicators of the condition's negative progression[20,23,29,43].

❖ This review explored insufficient rhodopsin regeneration, macular degeneration, and corneal damage as possible indicators of other severe ocular disorders that may arise if nyctalopia is left untreated.
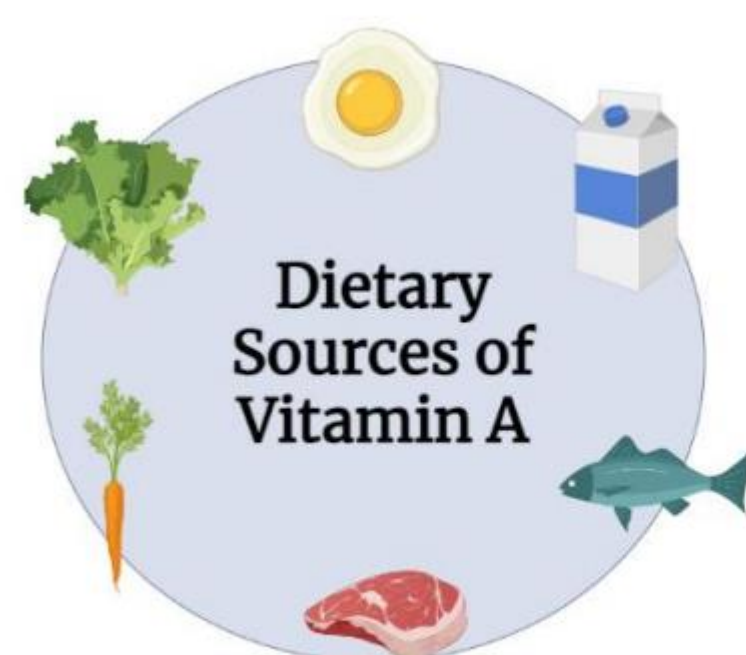

Figure 1: Schematic depicting the dietary sources of vitamin A, a micronutrient that the body itself cannot synthesize (Image Source: BioRender)

KEY REFERENCES

7. Carazo A, Macáková K,, Matoušová K, Krčmová LK, Protti M, Mladěnka P. 2021. Vitamin A Update: Forms, Sources, Kinetics, Detection, Function, Deficiency, Therapeutic Use and Toxicity. Nutrients. 13(5): 1703.

16. Gu H, Guo Y, Gu L, Wei A, Xie S, Ye Z, Xu J, Zhou X, Lu Y, Liu X, Hong J. 2020. Deep learning for identifying corneal diseases from ocular surface slit-lamp photographs. Scientific reports. 10(1): 17851.

40. Ruan X, Kang B, Qi C, Lin W, Wang J, Zhang X. 2021. Progenitor cell diversity in the developing mouse neocortex. Proceedings of the National Academy of Sciences of the United States of America. 118(10): e2018866118.

RHODOPSIN REGENERATION

❖ Rhodopsin is a photopigment that is synthesized from vitamin A and serves as a key component of photoreceptor rod cells through its function of sensing light in dimly-lit conditions[23,24].

❖ Rhodopsin regeneration relies on vitamin A being present in its biologically active form as 11-*cis*-retinal[14,49].

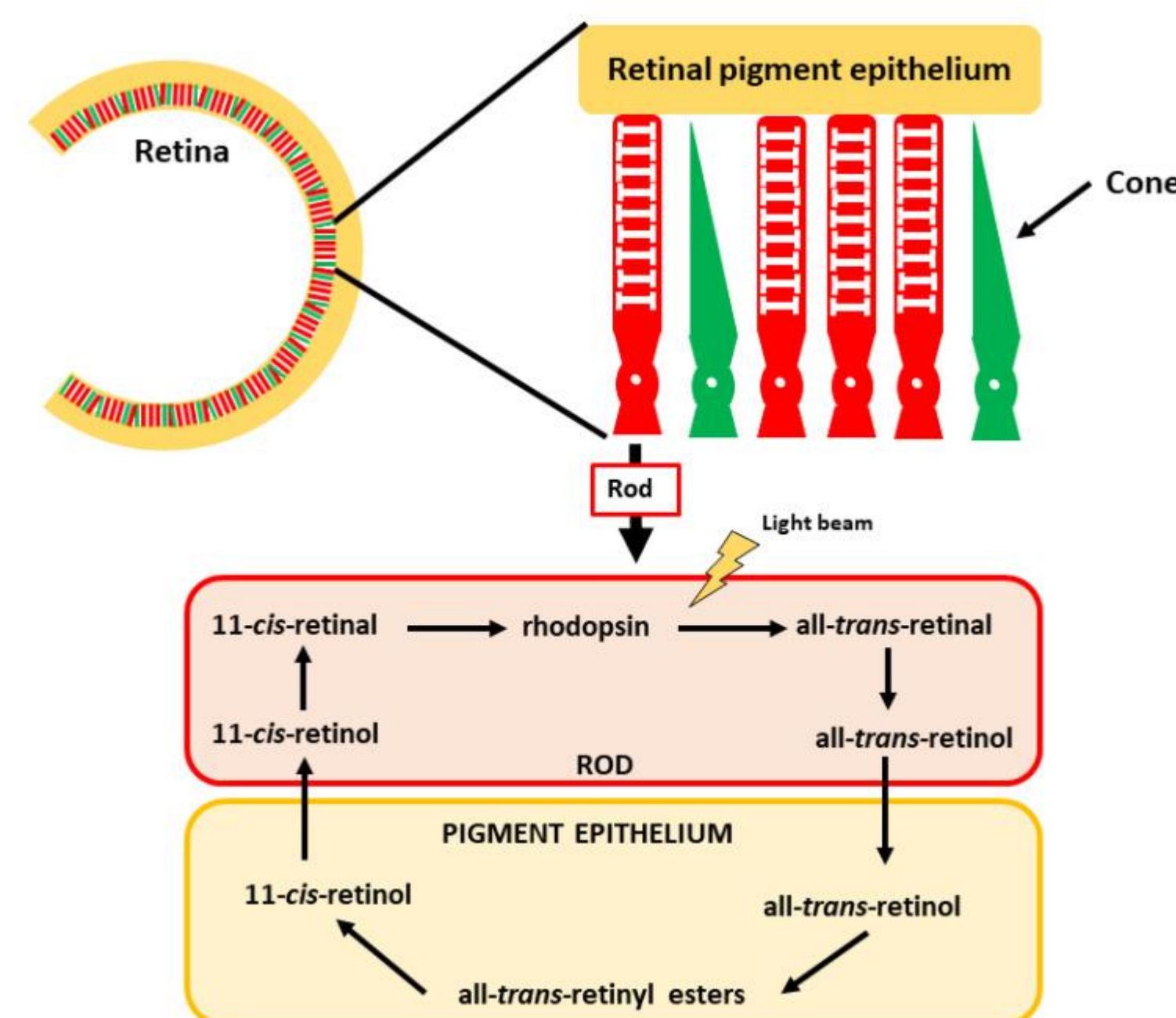
Figure 2: Mechanism of rhodopsin regeneration in rod photoreceptors using vitamin A derivatives (Image Source[7])

❖ Though the extent of rhodopsin regeneration required for visual acuity remains unknown, insufficient rhodopsin regeneration was recognized as a possible indicator of developing other ocular disorders[21,26,48,50].

MACULAR DEGENERATION

❖ The macula of the human eye is the center of the retina and accounts for central visual acuity in daylight[11,39].

❖ For age-related macular degeneration, key factors that (aside from aging and hereditary influence) include the effects of oxidative stress and nutritional deficiencies on retinal function[11,3,33].

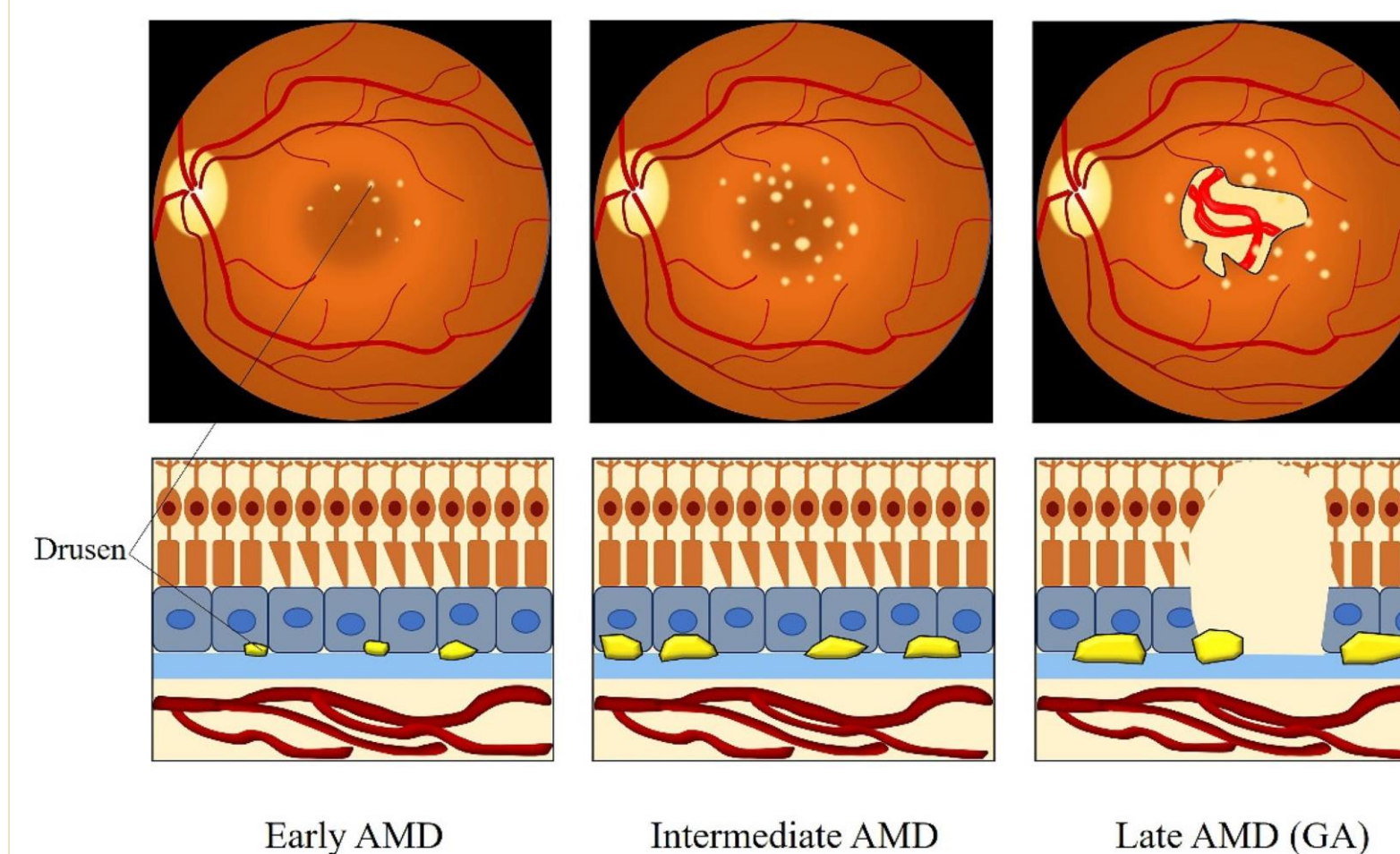❖ Rate of progression of macular degeneration is a value that has not yet been quantified[3,34].

Figure 3: Schematic illustrating the stages of age-related macular degeneration depicted by increasing severity and resulting negative impacts on the macula (Image Source[40]).

❖ In vitamin-A related nyctalopia, there seems to be an increased risk of progressive macular degeneration that can result in overall vision loss as a more severe ocular disorder[34,51,57].

COMPLETE REFERENCES

CORNEAL DAMAGE

❖ The cornea is located at the very front of the eye and allows light to pass through and enter the eye[49].

❖ Vitamin A, as an all-*trans*-retinoic acid maintains structure of conjunctival and corneal epithelia to prevent corneal xerosis, corneal ulcers, and corneal scarring[10,46].
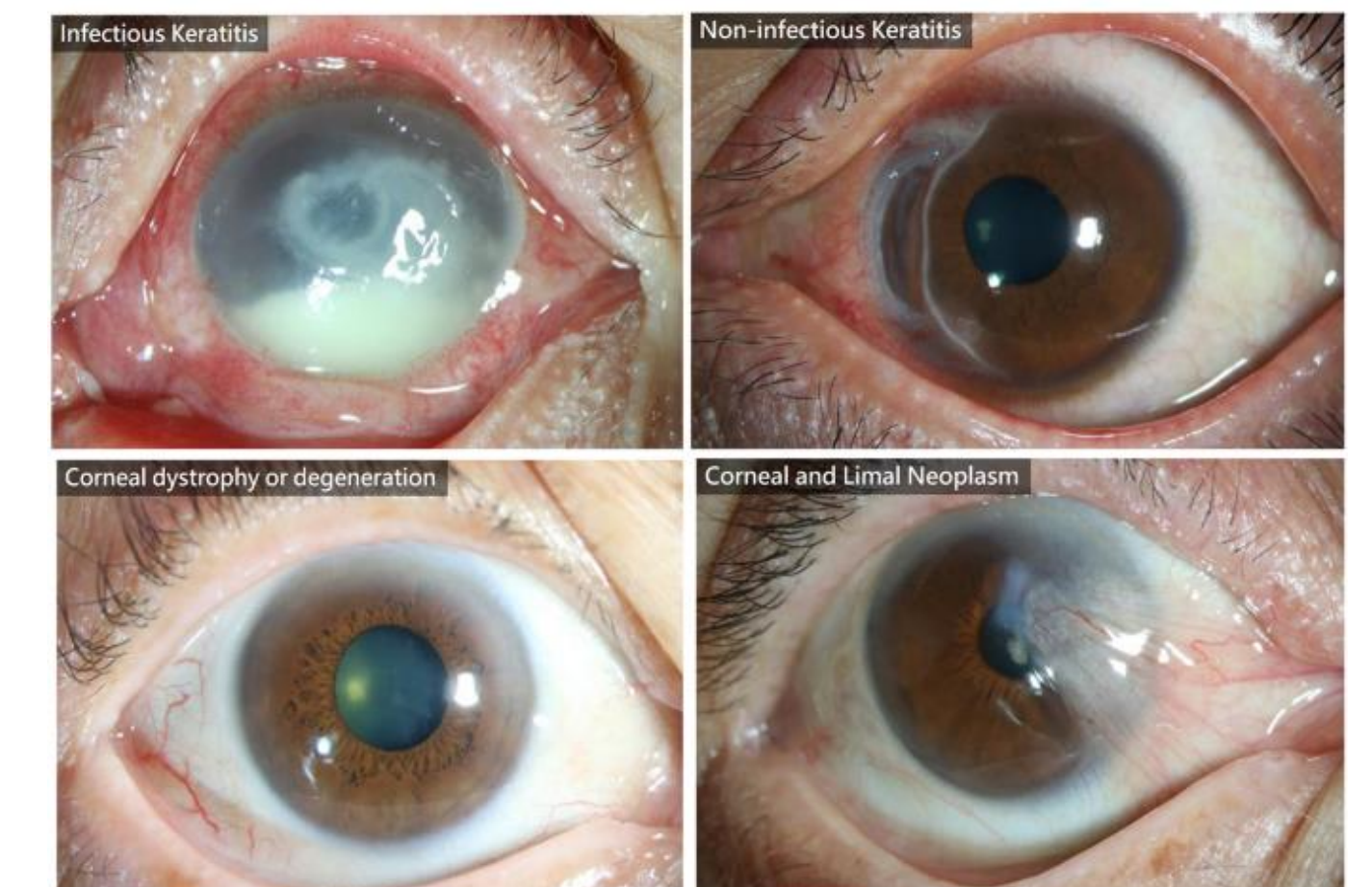

Figure 4: Common corneal diseases associated with cases of severe vitamin A deficiency (Image Source[16]).

❖ Severe nyctalopia may contribute to the negative progression of other ocular conditions, such as corneal ulceration[4,16,19,23].

CONCLUSIONS & FUTURE DIRECTIONS

❖ Insufficient rhodopsin regeneration, macular degeneration, and corneal damage may serve as possible (but not guaranteed) early indicators of further ocular damage.

❖ Vitamin A deficiency is not as common in developed countries as it is in developing countries, however, it is the leading cause of blindness worldwide

❖ Future research should quantify the minimum rate of rhodopsin regeneration for visual acuity and explore treatment options aside from vitamin A supplementation.