

Important of sight for the purpose of survival biology essay



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The importance of sight has been one of the most taken for granted systems in the human body. Sight, like the other four senses, plays an important role in the survival of an individual. In primitive humans, a loss of vision would make predator avoidance and food gathering difficult. Hence, there is an evolutionary pressure to maintain vision even when the eye sustains injury. While the eye is highly developed, certain post trauma mechanisms have evolved in such a way that our visual axis will not be altered, which would normally lead to instant blindness. Damage done to any normal part of the body usually leads to some sort of immunological response, including inflammation caused by the lymphocytes. Due to the physiology of the ocular system of mammals, the cornea cannot sustain inflammation, which can lead to the changing of the visual axis, thus leading to blindness. In primitive man, blindness could potentially lead to the individual's death. In order to prevent this, certain immunological responses are suppressed in the cornea, allowing vision to remain. Keratitis is the clinical diagnosis of inflammation of the cornea, which if left untreated, can lead to blindness of the patient. This paper will use the Darwinian Medical approach and the Adaptationist Program to discuss the implications of the suppressed immune response in development and treatment of keratitis and the various microbial and mechanical causes thereof.

In order to understand topics covered in this paper, a basic explanation of structures of the eye, their functions, as well as mechanisms and associated pathogens must be explained. Keep in mind, what will be mentioned is a buildup all to save the visual axis. The main anatomical focuses of the eye

for this paper are the cornea and the anterior chamber. Concluding this will be a brief description of Darwinian Medicine and the Adaptationist Program.

The cornea has two main functions and is composed of five layers. It acts as a protective membrane for the eye. The five layers consist of the following, in order from anterior to posterior,

“ an external stratified squamous epithelium, an anterior limiting membrane (Bowman’s membrane, the basement membrane o the stratified epithelium), the stroma, a posterior limiting membrane (Descemet’s membrane, the basement membrane of the endothelium), and an inner simple squamous endothelium.” 1.

The main functions of the cornea are to act as a protective membrane as well as to be the transparent window that allows light to enter through the eye to the retina. This unique transparency is due to the uniformity of the cell structure, being devoid of blood vessels, and being in a constant state of dehydration. If the epithelium is damaged, there is only a temporary regional build up of watery fluids in the stroma. However, if trauma is severe enough to expose any corneal layer below the epithelium, the cornea then becomes susceptible to infection of a variety of pathogens. These include, but are not limited to the following: bacteria, fungus, amoeba, and herpes virus. 2.

Without medical intervention, the basic stages of corneal infections are as followed: trauma, entrance of pathogen, inflammation of the cornea, ulceration, loss of vision, and even possibly loss of the eye.

Located between the endothelium of the cornea and the iris, is a fluid filled cavity called the anterior chamber. The anterior chamber of the eyeball is <https://assignbuster.com/important-of-sight-for-the-purpose-of-survival-biology-essay/>

filled with thick liquid-like substance called the aqueous humor. Its primary function is to maintain a normal intraocular pressure as well as provide nutrition for the tissues with no veins attached to them. In the anterior chamber, specifically the aqueous humor, there is a presence of a wide variety of immunoglobulins, as well as a wide variety of immunosuppressive substances such as transforming-growth-factor- β and macrophage-migration-inhibitory-factor. A theory deemed “ Anterior-chamber associated immune deviation” will be discussed later in this paper alongside with ocular-immune privilege. 3.

The Darwinian Medical approach looks at both proximate, biological causes, as well as the ultimate, evolutionary causes to explain a disease or an immune function such as a fever. Ultimate causes are usually more complex in their explanations, which include defense, infection, novel environment, genes, design compromise, and evolutionary legacy – all of which are evolutionary driven by four forces: natural selection, mutation, gene flow, and genetic drift. Evolutionary causes of an excessive and uncontrolled defense mechanism can affect the risk of the disease. Other risk factors include losing the evolutionary arms race, the preservation of an allele that is harmful, and the result of evolutionary constraints.

While keratitis is classified as an infection, it is actually an immune response related to the infiltration of a pathogen in the cornea. As stated above, keratitis is the inflammation of the cornea. Symptoms include mild to severe pain in the eye, redness of the eye, opaque cornea, photosensitivity, and tearing. Clinical diagnosis of keratitis is done through examination using a slit lamp and proper illumination, Fluorescein stain to detect superficial <https://assignbuster.com/important-of-sight-for-the-purpose-of-survival-biology-essay/>

corneal lesions, and laboratory examinations of corneal scrapings to detect pathogens. 2. Inflammation caused by pathogens is potentially harmful — leading up to corneal ulceration, loss of the visual axis, and potentially blindness. The inflammation however is the lesser of two evils, for without having this immune response, the sight of the infected would be doomed to blindness. While this is true, an eye's last-ditch effort to remove the pathogen leads to over-inflammation and ulceration of the cornea. At that point, unless a corneal transplant is done alongside with medicine to kill the pathogen, the eye has given up and the host goes blind. To regulate inflammation and prevent ulceration, it has been hypothesized that there is design compromise called ocular immune privilege in the eye that regulates inflammation up to a certain point. This will be discussed later.

The epidemiological qualities of keratitis fluctuate etiologically as well as geographically. Keratitis has risen in both developing countries as well as modernized countries, afflicting people worldwide with no restrictions based on economic status. Thousands of patients each year are diagnosed with some form of pathogenic keratitis, having each pathogen found in particular environments found worldwide. Anyone involved in agriculture is usually at risk for fungal keratitis. Anyone wearing contacts are at an even higher risk for not only fungal keratitis, but also bacterial and amoeba induced keratitis. However, anyone who has any sort of ocular trauma led to lesions in the cornea is susceptible to any form of microbial keratitis. 2.

The evolutionary legacy of ocular immune privilege is the result of evolutionary constraints and design compromises. In order to preserve the function of the eye, inflammation is regulated by the host's adaptive

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immunity, specifically called ocular immune privilege. Immune privilege has been recognized in only three organs; the testes and ovaries, the brain, and the eye. 5. Coincidentally, these are some of the most important organs in the body related to survival and spreading of one's genome. " Adaptive immunity is compromised of lymphocytes that throughout life generate unique receptor molecules that recognize with extraordinary specificity molecules expressed by invading pathogens." 3. (pg 11). It is important to understand this concept to elucidate the mechanisms of ocular immune privilege and ACAID.

Ocular Immune privilege was first described about 130 years ago. However, its importance was not recognized until the early 1940s by P. B. Medawar and his colleagues. During the 1970s, it was discovered that ocular immune privilege was caused by anatomical, physiological, and immunoregulatory processes, which prevent the introduction and expression of immune-mediated inflammation. Many ophthalmological researchers agree that ocular immune privilege is " an adaptation for reducing immune-mediated injury to ocular cells that have limited or no capacity for regeneration." 6. The three major mechanisms of ocular immune privilege are as followed: "(1) there are anatomical, cellular, and molecular barriers in the eye; (2) eye-derived immunological tolerance (ACAID); and (3) immune suppressive microenvironment in the eye." 5. Anterior chamber-associated immune deviation, or ACAID, is directly related to the ocular immune privilege theory. " ACAID is characterized by impaired antigen-specific delayed-type hypersensitivity and reduced production of complement fixing antibodies." 3. It is an observable fact that allows the antibody response but not the cellular

responses mentioned above. 5. The discovery happened when there was a prolonged survival of genetically different transplanted tissue survived in the anterior chamber of the eye. The failure of the immune system to bring forth an immunological response composes the characteristics of immune privilege. This is the reason why corneal transplants are one of the most successful, and least rejected tissue transplant clinically practices. Most tissue transplants are rejected due to inflammation — however, the cornea has a weaker immune response caused by low antigenicity, the difference between corneal versus other tissue grafts. 7.

The mechanisms of ACAID involve both the eye and the spleen. Transforming Growth factor TGF- β 2 and thrombospondin TSP-1 located in the anterior chamber are involved in the initiation of mediation of ACAID. Through this, there is an attraction of regionally located natural killer T cells, which bind to CDQd molecules to present the antigens. When these cells come in contact with marginal zone B cells, clusters are formed which then “ differentiate into ACAID-inducing regulatory T cells.” 5. A recent discovery made by Molly E. Skelsy and colleagues, concluded that β 2 T cells are needed for ocular immune privilege and corneal graft survival. The study used mice treated with anti- β 2 Ab failed to develop ACAID concluding the injection of spleen cells. It was concluded that these T cells were required for the creation of regulatory T cells. By blocking the creation of β 2 T cells, Skelsey showed that there was a profound increase in corneal transplant rejections. 8.

Another recent discovery was that thymocytes, cells created by thymus that generate into T lymphocytes, are also necessary for the induction of ACAID. Thus the sustainment of immune privilege in the eye is done through the

mutual aid of various cells from organs other than the eye itself. 5. The adaptive immunity is expressed “ in the form of humoral immunity mediated by antibodies produced by B lymphocytes, and in the form of cellular immunity mediated by T lymphocytes.” 3. (pg 15)

Clearly, ocular immune privilege isn't something that just arose out of nowhere. It has been an evolutionary legacy, because whatever beneficial implications it had, leading up to ACAID, must have been immediately beneficial for it to exist throughout the evolution of many mammals such as humans and even mice.

In 2008, Xiaoyong Yuan and colleagues did a study to compare the gene expression patterns in uninfected and fungus-infected mouse corneas at the onset of *Candida albicans* fungal keratitis. *Candida albicans* related corneal infections cause an inflammatory response, which has been known to permanently impair vision in half of all eyes affected, including those with therapy. Infected eyes were observed and corneal transcriptomes were categorized to suggest pathways contributing to corneal inflammation during *Candida* related keratitis.

Through the use of gene microarray, the host's gene expression during the early stages of this keratitis was also observed in mouse models. RNA isolated from the corneas one day after inoculation were used for reverse transcription of the RNA which would then be used in a quantitative real-time RT-PCR to multiply the amount of DNA created. Gene expression levels were calculated for both the experimental group and the control group. When comparing the two groups, a total of 45, 102 genes were detected. Of those

genes, 3, 977, roughly 8. 82% of the infected corneas were significantly regulated. Of those genes, 1987 were upregulated and 1, 990 were down-regulated. A total of 3. 71% were differentially expressed, 1, 075 being upregulated and the other 597 being down-regulated. Specifically, there were 30 different genes being upregulated more than 100 fold. These genes were categorized as chemokines, metalloproteinases, interleukin cytokines, leukocyte chemotaxis and surface molecules, Ig receptors, Neuro-hormone mediators and many others. Simply stated, these gene expressions suggest that microbial keratitis involves the synchrony of various host processes that affect inflammatory and immune responses, intercellular communication, and cellular metabolism — in other words, ocular immune privilege and ACAID. 9.

Keratitis is a microbial affliction occurring globally. Bacteria, parasites, virus, and fungus cause the four main microbial causes for infection. These microbes are currently winning the at arm's race due to an increased virulence and re-infection after treatment. At the same time, because there have been changes in man's history, various novel environments have been associated with the etiology of all these infections. Looking at a study in a referral centre in South India from September 1999 through August 2002, MJ Bharathi and colleagues observed and calculated the statistics of keratitis in that referral centre. Of 3183 corneal scrapings evaluated, 1095(34. 4%) were fungal related, 1043(32. 77%) were bacterial related, 33(1. 04%) were acanthamoeba related and 76(2. 39) were both bacterial and fungal related. Of the 1043 bacterial related infections, the predominant isolated bacteria were Streptococcus. Males were 56. 76% of cases and females were 43.

24%, thus showing that sex doesn't affect the infiltration rate. In the study, 60.2% patients were over the age of 50 were affected significantly more than patients under the age of 50. Roughly 16.97% of corneal injuries were due to soil/sand, compared to the 11.03% caused by other materials, showing a statistical significance between the two. Seasons also affected the rate of infections - showing a lower incidence of bacterial keratitis from the months of June to September. 10.

The epidemiology of bacterial keratitis varies based on geography. One could acquire keratitis from numerous gram-positive or gram-negative bacteria, such as *Serratia*, *Pseudomonas*, and *Staphylococcus*. Once the bacteria has touched base with the cornea, it colonizes the host's cells by using adhesins at the surface of the epithelium. The adherence of these three bacteria to the corneal epithelium is significantly higher than any other bacteria, which explains their high frequency of isolation. Several bacteria have also displayed adhesins on pili and nonfimbriae structures to recognize carbohydrates on host cells. Recently, there have been emerging cases of resistance among pathogens, requiring the emersion of a stronger antibacterial to eradicate it. 11.

The advent of contact lenses has created a novel environment for the infiltration of many bacterial pathogens. In the United States, there are approximately 25,000 cases of infectious keratitis annually. There are roughly 2-4 infections per 10,000 soft contact lenses users, and 10-20 infections per 10,000 extended-wear contact lenses users. 14. A study done by T. Bourcier and colleagues has identified predisposing factors of bacterial keratitis. After analyzing 300 cases, contacts were the main risk factor, <https://assignbuster.com/important-of-sight-for-the-purpose-of-survival-biology-essay/>

occurring in 50.3% of the study group, with 83% of bacteria being gram positive, and 17% being gram negative. 12. Another study of a case report done by Konstantinos Tsaousis and colleagues concluded that the incidence of bacterial keratitis can be reduced by maintaining high standards of lens hygiene and following the recommended guidelines to safely wearing contacts. 13.

In the past, fungal keratitis has been a major ophthalmological problem in the tropical regions of the world. 16. Of all of the fungus related to keratitis, there are two classifications of infiltrates - yeast and filamentous fungi. The three main isolates of fungus in fungal keratitis are *Aspergillus*, *Fusarium*, and *Candida*. While the most common of isolate reported has been *Aspergillus*, ranging from 27-64%, *Fusarium* comes to a close second (6-32%). Like bacterial keratitis, contact lenses wearers are at a higher risk of fungal infection. In recent news, on March 8, 2006, the CDC began an investigation of the use of Bausch & Lomb ReNu contact lens solution. The solution had been related to a series of 130 confirmed cases of *Fusarium* Keratitis, which resulted in 37 corneal transplant surgeries. Most fungal related incidences however are usually related to agriculture. Since fungus are found in soil and on plants, the probability of infection after ocular trauma increases if one is tending to their crops. Once the fungus accesses the corneal stroma, they multiply and cause tissue necrosis leading to the onset of keratitis and the loss of stromal opacity. 15.

Acanthamoeba related keratitis is usually derived from standing water or mud, with an increased risk in contact users. Incidence per million contact lens users includes 333 in Hong Kong, 1 in USA and 149 in Scotland 14. The <https://assignbuster.com/important-of-sight-for-the-purpose-of-survival-biology-essay/>

abnormally high incidence in Scotland is due to the fact that there are many water towers, holding standing water, a novel environment for the *acanthamoeba*.

Survival in the wild is not only based on one's ability to escape a predator, but also one's ability to detect the predator. The up keeping the visual axis is one of the most important abilities of the eye's immune abilities — for without sight, many mammals would be at disadvantage. Keratitis, the inflammation of the cornea, has probably been around since the dawn of man, and more specifically, the dawn of agriculture. If injury to the eye were to be sustained, the cornea would become inflamed. Normally, corneal cellular layers would be impaired, leading to a loss of the visual axis. However, it has been observed that there is a key mechanism that has developed over time in order to save one's sight. There is an ocular immune privilege, considered to be an evolutionary legacy as well as a design compromise, in the anterior chamber of the eye, which limits certain immune functions to prevent the loss of vision. The microbial pathogens cause these infections ranges from bacterial, to fungal, viral, and amoebic have been detected around the world, causing countless keratitis infections. Novel environments, such as contact lenses, have created the perfect environment for these pathogens to culture on – especially if proper care protocols haven't been taken. While most of these infections are treatable, in the long term, the microbes are winning the at arm's race. With increase resistance to anti-bacterials/fungals, pathogens will only become more virulent. From an epidemiological standpoint, microbial keratitis poses a serious threat for future infected patients, occurring world-wide.

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