Importance of staphylococcus aureus to humans biology essay

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The bacterial genus to be isolated and identification in this project is Staphylococcus. This genus has been chosen for the reason of its abundance on the skin of mammals and the pathogenic nature of one of its member, Staphylococcus aureus. Apart from skin infections, Staphylococcus aureus could mutate to Methicillin-resistant Staphylococcus aureus (MRSA). In both cases, these give rise to medical implications. In addition, the distinctive features of Staphylococcus aureus from other species in the genus allow it to be easily isolated and identified via culturing and biochemical tests.

Staphylococcus was first discovered in 1880 by Alexander Ogston (Paniker 2005, p. 192). Currently, more than 30 different species of the genus has been identified (Deurenberg & Stobberingh 2008). The name “ Staphylococcus” was derived from Greek, with the prefix “ Staphylo” referring to “ bunches of grapes “ and the suffix “ coccus” referring to “ granule” (Ryan & Ray 2004). As the meanings suggest, bacteria from Staphylococcus are circular-shaped and their arrangement resembles bunches of grapes when observed under a microscope. Typically, a Staphylococcus has a diameter of approximately 1Î¼m (Willey, Sherwood & Woolverton 2011, p. 562).

The aim of the project is to isolate Staphylococcus aureus from the genus from a bundle of cat hairs and verify its identity via microscopic examination. No human specimen is used due to the potential pathogenic property of Staphylococcus. It is intended that a pure culture of pathogenic Staphylococcus aureus is obtained. For the purposes of this project, the importance of Staphylococcus aureus to humans, its classification in terms of morphology, physiology and structure, methods of isolation and identification by biochemical tests would be the objectives to be addressed.

Importance of Staphylococcus aureus to humans

The importance of Staphylococcus aureus to humans would be outlined by a review of the cell structure, cell physiology and environmental niches, followed by the medical implications of Staphylococcus.

Cell structure

Staphylococcus is a cocci bacterium. As a member of the Bacteria domain, it is expected that Staphylococcus has bacterial cell structure. In other words, it lacks nucleus and membrane-bound organelles. The structural elements in a cell of Staphylococcus should include a cell membrane, cell wall, ribosome and nucleoid (Campbell et al. 2009, p. 98). On the other hand, it is worthwhile to note that Staphylococcus does not have flagella and spores (Paniker 2005, p. 193).

In addition to the above structures, Staphylococcus aureus possesses surface proteins that help attachment to proteins such as the fibronectin and fibrinogen-binding proteins involved in blood clotting (Baron 1996). This cellular property may explain the pathogenic nature of Staphylococcus aureus, as invasion might occur via wounds and abrasions.

Cell physiology

The cell physiology of Staphylococcus covers temperature, pH, osmolarity and oxygen requirements, as well as cell division.

Staphylococcus typically grows from a temperature of 20oC to 40oC, with optimum temperature being 37oC (Todar 2000). Concerning the optimum pH for metabolism, it ranges from 7. 4 to 7. 6 (Paniker 2005, p. 193). For osmolarity, Staphylococcus requires a water activity of at least 0. 85 for substantial growth (Todar 2000).

As for oxygen requirement, Staphylococcus is facultative anaerobic (Willey, Sherwood & Woolverton 2011, p. 562). This implies Staphylococcus can grow regardless of the presence of oxygen, but the presence of oxygen would be more favorable.

Environmental niches

The environmental niches of Staphylococcus can be addressed by its interactions with other organisms as to where it is found, how it synthesizes nutrients for growth and mutation.

Staphylococcus is commonly found on the skin and mucous membranes of animals with stable body temperatures, including humans (O'Gara and Humphreys 2001, p. 583). The salty environment along skin surface due to the production of sweat may account for the abundance of Staphylococcus, since its enzymatic activity is at alkaline pH (Blood et al. 2007). The prominent bacteria from the genus include Staphylococcus aureus, which colonizes in nasal cavity, larynx and on the skin surface (Andersson, Lindholm & Fossum 2011). This may outline a parasitic relationship, in which Staphylococcus is the parasite and the animal supporting its growth is the host (Willey, Sherwood & Woolverton 2011, p. 725).

In the presence of oxygen, Staphylococcus utilizes glucose to carry out cellular respiration, and electrons are passed on to the terminal acceptor, oxygen (Willey, Sherwood & Woolverton 2011, p. 562).

When oxygen is lacking or absent, Staphylococcus may undergo fermentation and lactic acid is the usual product (Willey, Sherwood & Woolverton 2011, p. 562). In the process, glucose is converted into substrate pyruvate, followed by its binding to the cofactor Nicotinamide Adenine Dinucleotide (NAD+) to produce lactic acid (Campbell et al. 2009, p. 178)

The interactions of Staphylococcus with the environment may also be underlined by mutation, which often occurs with Staphylococcus aureus. An example would be Methicillin-resistant Staphylococcus aureus (MRSA), a Staphylococcus aureus that is resistant to the antibiotic, Methicillin (Willey, Sherwood & Woolverton 2011, p. 562). The mutation is caused by an alteration of the methicillin-resistance gene (mec A) coding for a penicillin-binding protein (Davis 2011). This results in failure of antibiotics to cure infections caused by Staphylococcus aureus, which will be addressed in the medical implication section.

Medical implications of Staphylococcus

Staphylococcus can present a great diversity of environmental, medical or biotechnological implications.

Being a mesophile, Staphylococcus can carry out metabolism under normal room temperature. Together with the abundance of warm-blooded animals which act as hosts to provide a salty medium, it can be said that Staphylococcus has an environmental implication of ubiquity.

Statistics show that Staphylococcus aureus is present in 30% of healthy people (National Centre for Preparedness, Detection and Control of Infectious Diseases 2003). Though Staphylococcus may colonize on the skin surface of the host without causing any harms, its ubiquity can still give rise to various medical issues. The MRSA mentioned previously would be one of the problems associated with Staphylococcus. Apart from methicillin, MRSA could show resistance against many other antibiotics such as penicillin and amoxicillin (Agodi et al. 1999, p. 638). The ineffectiveness of existing antibiotics to cure MRSA infections has resulted in fatality, and it is usually characterized by the incidence of septic shock and pneumonia (Klevens et al. 2007). A rapid increase of MRSA infections has been observed over the decades. The rate of hospitalized MRSA infections was only 2% in 1974 but this figure increases dramatically to approximately 40% in 1997 (Lowy 1998). This causes deaths of 19000 in the United States of America annually (Klevens et al. 2007). As Staphylococcus colonies on skin surfaces and mucous membrane, skin infections and diseases associated with mucous membranes could be another medical implication. It is known that Staphylococcus aureus may cause Scalded Skin and Toxic Shock syndromes. Moreover, it may cause pneumonia, urinary tract infections, food poisoning (Gill et al. 2004, p. 2426).

Classification of Staphylococcus

The classification of Staphylococcus can be reviewed in terms of its morphology and some of the physiological properties stated above.

Morphology

The morphology of Staphylococcus can be described as cocci gram positive bacteria arranged in a cluster. This can be explained by its property of cell wall and its behavior in cell division.

The cell wall of Staphylococcus shows a gram positive reaction, which indicates its composition is essentially a thick layer of peptidoglycan (Todar 2011). This property of cell structure helps the identification of Staphylococcus. Moving on to cell division, it can be predicted that Staphylococcus reproduce by binary fission. The reason for its cluster formation may be explained by its capability of undergoing binary fission in multiple planes with daughter cells remains proximal to each other (Paniker 2005, p. 192). Though the daughter cells remain in close proximity, the positions of attachment could vary and this leads to cluster being formed irregularly (Todar 2011).

Physiological properties

In terms of thermal requirement, Staphylococcus is a mesophile. Regarding pH requirements, it is a neutrophile. Being a facultative anaerobe, Staphylococcus is catalase positive. The absence of flagella indicates that Staphylococcus is a non-motile bacterium. In addition, Staphylococcus aureus is coagulase positive but not for other species in the genus.

As light is not readily available on skin surface and mucous membranes, it is proposed that Staphylococcus obtain energy via organic chemical compounds. Hence it is regarded as a chemotroph (Willey, Sherwood & Woolverton 2011, p. 137). The facultative anaerobic property of

Staphylococcus may lead to a deduction that it utilizes organic carbon as the source of electron when oxygen is present. Though some Staphylococcus may use reduced forms of inorganic nitrates to generate electrons, its preference towards an aerobic atmosphere should define it as an organotroph (Willey, Sherwood & Woolverton 2011, p. 137, 562). When comes to carbon source, Staphylococcus is a heterotrophy (Kumar, Hatha & Christi 2007). That is to say, it attains its carbon source by converting organic substances for synthesis via oxidation (Voet, D, Voet, JG & Pratt CW 2008, p. 449). To sum up, Staphylococcus should be one of the members of the microbial group Chemoorganotrophic heterotrophs.

Methods of Isolation of Staphylococcus

The methods of isolation of Staphylococcus would include growing in medium followed by streak plating.

Growth media

To ensure optimum growth of colonies, Staphylococcus should be enriched in nutrient broth with sodium chloride (NaCl) before plating on a nutrient agar. A nutrient broth normally consists of beef extract and peptone as fuels for growth (Willey, Sherwood & Woolverton 2011, p. 148). The addition of salt allows a selective medium for Staphylococcus as it predominantly grows in salty environment.

Alternatively, a growth medium can be done via a Mannitol salt agar (MSA), which consists of 7. 5% of NaCl and a pH indicator. MSA essentially acts as both a selective and differential medium. NaCl selects for saline-favored Staphylococcus and the pH indicator differentiates between Staphylococcus aureus and Staphylococcus epidermidis. Differentiation can be illustrated by the fact that Staphylococcus aureus utilizes mannitol in the agar for metabolism, and the generation of acidic product is indicated by a yellow color. However, this phenomenon does not apply to non-pathogenic Staphylococcus (Willey, Sherwood & Woolverton 2011, p. 147).

Streak Plating

Following enrichment, Staphylococcus in the medium can be transferred to an agar plate with nutrient broth and salt, by employment of aseptic techniques. At the same time, a transfer to an agar plate with only nutrient broth should be performed as a control set-up. This is to ensure the effectiveness of the selective media because other bacteria could grow on the agar plate if the medium was not set up properly.

Afterwards, the plates would be incubated for a week. Incubation should be done at 37oC as it is the optimum temperature for Staphylococcus to grow. Plating and incubation should be repeated a few times to make sure that the colonies grown are pure.

Identification by biochemical tests

The identity of Staphylococcus cannot be confirmed by carrying out the gram reaction alone due to the fact that a great variety of bacteria from other genus may also show gram positive reaction. Therefore, some biochemical tests have to be performed to verify that the bacteria isolated is in the genus of Staphylococcus and it is of the species Staphylococcus aureus. These tests include catalase, motility and cogulase.

First of all, as Staphylococcus aureus is facultative anaerobic, it is expected that it contains enzymes to break down harmful products such as free radicals generated along its aerobic pathway (). In this case, the enzyme of interest is catalase, in which its presence allows the breakdown of toxic hydrogen peroxide (H2O2) into oxygen and water (). Therefore colourless gas bubbles can be observed when H2O2 is added to a colony of Staphylococcus aureus.

Moreover, as Staphylococcus aureus is non-motile, motility test can be performed. In a motility medium supplied with carbon source, a pink color can only be observed along the stab line (). This essentially means that the growht Staphylococcus aureus is localized and its colonies are not motile.

Furthermore, the identification test between Staphylococcus aureus and other bacteria from the genus would be based on its reaction with coagulase. Staphylococcus aureus readily coagulates plasma but not for others species in the genus (Willey, Sherwood & Woolverton 2011, p. 750). To ensure accuracy of the test, it is preferable to test on colonies extracted from culture plates that are known to contain coagulase positive Staphylococcus aureus and coagulase negative Staphylococcus epididymis respectively. The former acts as a positive control, while the latter acts as a negative control.

Conclusion

In conclusion, Staphylococcus is a ubiquitous bacterial genus that can pose various medical implications and it can be grown, isolated and identified based on its, environmental niches, morphology, physiological and structural characteristics. The aims of isolation and identification of Staphylococcus aureus can be achieved by a review of the four objectives as summarized below.

Firstly, it is often found on epidermis of animal skins including humans and its ability to metabolize optimally at 37oC and at pH of 7. 4-7. 6 makes it a potential pathogen to humans. In particular, the species Staphylococcus aureus can cause a great diversity of diseases and the mutated Methicillin-resistant Staphylococcus aureus could be fatal owing to its resistance to most antibiotics.

Secondly, it can be classified by in terms of morphology and some of the physiological characteristics. Its morphology is gram positive cocci bacteria growing in clusters. It is a mesophile, nuetrophile and facultative anaerobe. It is catalase positive and only Staphylococcus aureus is coagulase positive. The energy, electron and carbon sources of Staphylococcus aureus can be described as chemoorganotrophic heterotrophic.

Thirdly, regarding growth medium, the sample of cat hair should be enriched in a medium of sodium chloride before incubating on an agar plate of nutrient broth and salt at 37oC. The colonies should be streaked plated a few times to remove contaminants. This increases the efficiency of isolation of Staphylococcus aureus.

Lastly, Staphylococcus aureus can be identified by the catalase, motility and coagulase tests. It is expected that bubbling is observed as a positive result with the catalase test. As for the motility test, a negative test is expected. In other words, no growth is observed across the stab line. Clumping of plasma is seen as a positive result and this differentiates Staphylococcus aureus from other species in the genus.