Death Rays: How does duration of exposure to UV light inhibit the growth of bacterial colonies?

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Abstract
The widespread increase of antibiotic-resistant bacteria is a global issue with severe consequences if we do not find another method of controlling bacterial pathogens (Jorgensen et al., 2017). It is widely accepted that a reduction on the use of antibiotics would ameliorate this problem. This project investigates an alternative method for controlling bacterial growth using ultraviolet (UV) light to cause mutations in the bacterial cells (Conner-Kerr et al., 1998).

This investigation looks at the effect of ultraviolet exposure on E. coli bacteria. When bacterial cells are exposed to ultraviolet light, energy from the light is absorbed by the double bond between the pyrimidine bases (such as thymine and cytosine) in the DNA, causing the bond to open. This bond then re-forms with adjacent bases, causing a mutation in the DNA strand. While these mutations are generally addressed by repair mechanisms within the cell, if the bacterium is exposed to sufficient ultraviolet light this can cause mutations at a rate that cannot be repaired by these mechanisms. If the DNA damage is sufficiently extensive, the bacterium is unable to reproduce and the colony fails.

In this investigation, bacteria were exposed to a range of ultraviolet exposure times and the effect this had on the survival of the bacteria was measured. A range of exposures were investigated from 0 - 300 seconds. The results indicate that UV light could be used as an alternative to antibiotics in some situations.

Method

Apparatus: 30 nutrient agar plates; glass spreader; live E.coli dilution; safety glasses to protect eyes from UV light; disposable gloves; disposable sterile pipettes; Bunsen burner; 70% ethanol; germicidal UV-C light mounted 5 cm from the bench; stopwatch; permanent marker; 37°C incubator for bacterial culture plates

Procedure: Aseptic technique was used throughout to ensure the sterility of the plates as much as possible and to avoid contamination by environmental bacteria.

The sterile pipette was filled with live E.coli and the plates were inoculated with the bacteria using aseptic technique. A sterile spreader was then used to ensure the bacterial solution was spread evenly across the agar plate. Clear adhesive tape was used to secure the lid of the plate to the base. The plates were labelled at the edge with the permanent marker, indicating the sample number and the amount of time the plate would be exposed to the UV light.

A sample of five inoculated plates were exposed to UV light of wavelength 253.7 nm for each of 0, 15, 30, 60, 120 and 300 seconds. The plates were then incubated at 37°C for 24 hours and the bacterial colonies counted.

Results

<table>
<thead>
<tr>
<th>Time Exposed to UV light</th>
<th>Number of Colonies produced after 24 hours of incubation time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (S)</td>
<td>Plate 1</td>
</tr>
<tr>
<td>0</td>
<td>98</td>
</tr>
<tr>
<td>15</td>
<td>86</td>
</tr>
<tr>
<td>30</td>
<td>64</td>
</tr>
<tr>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>300</td>
<td>3</td>
</tr>
</tbody>
</table>

Exposure to UV light significantly reduced the number of colonies formed by the E-coli bacteria. Our results show a negative exponential relationship between the amount of time exposed and the number of bacterial colonies.

With no UV exposure, after 24 hours there were an average of 103 colonies. The results as we raised the exposure showed a drop in number of colonies finally reaching an average of 3.4 colonies able to grow after 300 seconds of UV exposure.

Conclusion

These results suggest that it might be possible for UV light to be used as an alternative to antibiotics in some situations; for example when disinfecting surfaces as an alternative to antibacterial sprays and wipes.

Reducing any use of antibiotics, however small, could be helpful in order to slow the development of antibiotic resistance. However, it should be noted that even after 300 seconds of exposure to UV light, some bacterial colonies remained. Different pathogens have a different susceptibility to UV light (Hu et al., 2012), therefore it will be important to investigate whether, with further exposure, all the colonies could be eradicated, or if different wavelengths of UV light have a different effect. If some colonies are able to survive irradiation with UV light, and these colonies then go on to reproduce, UV-resistant colonies would develop in the same way that antibiotic-resistant bacteria have flourished.

References