Introduction:

Ultraviolet (UV) light is a double-edged sword. On the one hand it is involved in converting the cholesterol derivatives, 7-dehydrocholesterol and ergosterol, to vitamin D$_3$ or vitamin D$_2$, respectively. These compounds are then converted to their respective active forms by liver and kidney enzymes. The active forms then act to increase serum [Ca$^{2+}$] by promoting intestinal absorption of dietary Ca$^{2+}$ and by stimulating Ca$^{2+}$ release from bone. Excessive [Ca$^{2+}$] from vitamin D intoxication, can result in aberrant calcification of kidneys leading to kidney stones, and promotes bone demineralization leading to easily fractured bones. The observation that the level of skin pigmentation in indigenous human populations tends to increase with their proximity to the equator is explained by the hypothesis that skin pigmentation functions to prevent vitamin D intoxication by filtering out excessive solar radiation. On the other hand, too much UV light from the sun, or sunlamps, can lead to a sunburn which can further lead to skin cancer. Additionally, too much UV light can cause cataracts and long-term aging and wrinkling of the skin.

UV light can be divided into three categories: UV-A, UV-B, and UV-C. Though tanning salons would have you believe that UV-A with longer wavelengths and thus lower frequency and energy are less harmful than the other two forms, researchers have found that these rays penetrate deeply into the skin and break down collagen, a predominant protein in skin. In addition to premature aging and wrinkling of the skin, long-term exposure is linked to skin cancer. UV-B is more energetic than UV-A and is most intense in summer. This form of UV is the most common cause of sunburn, skin cancer and cataracts. UV-C is the most energetic of the three and would be most damaging except it is filtered out by the ozone layer.

Sunscreens and sunblocks contain chemicals that absorb or block UV rays. The sun protection factor (SPF) is a number that refers to how long a person can stay in the sun before developing a sunburn. For example, if you begin to burn after 15 minutes with no protection, you should be able to stay out 15 times longer, or 225 minutes, if you use a sunscreen with a SPF 15 rating. Most sunscreens absorb primarily UV-B rays. To block UV-A rays, pigments such as titanium dioxide, or the compound azobenzone, must be added.
In order to evaluate the effectiveness of a sunscreen, we need a procedure that allows us to monitor the effects of UV radiation. One method is to allow benzophenone, which is soluble in isopropyl alcohol (2-propanol) to be converted to the insoluble compound, benzopinacol by the action of UV light. The reaction is shown below:

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\begin{align*}
2 \text{benzophenone} + \text{CH}_3\text{CHCH}_3\text{OH} & \xrightarrow{\text{UV light}} \text{benzopinacol} + \text{CH}_3\text{CCH}_3\text{O} \\
& \text{alcohol} & \text{acetone}
\end{align*}
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A direct comparison can be made by observing the amount of solid formed with and without the sunscreen after exposure to UV light. If UVlight is unable to reach the reactants, no reaction will occur.

**Procedure:**

Your group should obtain a Petri dish and label the bottom half with a Sharpie® marker pen. The label should contain your section number, group member initials and the identity of the sunscreen agent you are testing; each group should test a different one. Place 10 ml of the benzophenone/isopropyl alcohol solution into the Petri dish. Carefully, cover the Petri dish with a single layer of plastic wrap and secure with a rubber band. Carefully, with out disturbing the solution, make the plastic surface as smooth as possible. Coat the outer surface with the sunscreen preparation you are testing, ensuring that the preparation uniformly covers the entire surface. Your instructor will prepare a control; 10 ml of the benzophenone/isopropyl alcohol solution into the Petri dish covered by the plastic wrap only. Carefully place the Petri dish under the UV lamp. Your instructor will remove all the samples when the control begins to show evidence of crystal formation and store them in the dark until the following week.

The following week obtain your sample. Do a visual inspection of the your sunscreen preparation compared to the control. Estimate the relative amount of crystals compared to the control, i.e., the same amount of crystals, a little less, about three-fourths as much, about half as much, about one-fourth as much, a lot less, or no crystals at all.