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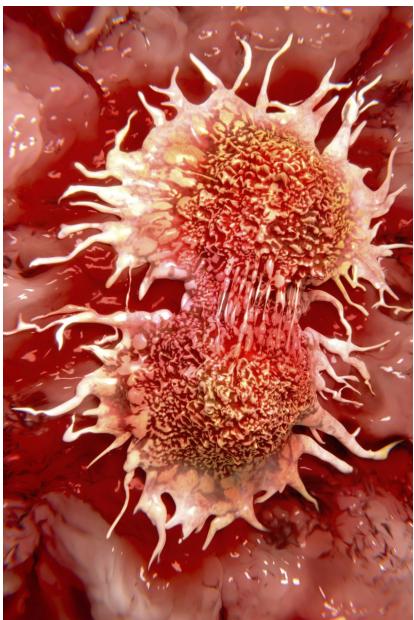
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If the bad guys were good

Cancer is a life threatening disease. Over 7.6 million people fall victim to this disease each year. Out of which, 4 million people die prematurely (aged less than 60). Most of these die because of late detection, which then grows out to be a very large tumour, too late to operate. In other cases, the cancer relapses and comes back stronger, immune to medication like chemotherapy and radiation. Cancer could be dubbed as the 'good guys gone bad'. Each second, thousands and thousands of our living cells die, which is why our cells need to divide and replicate to keep us living. This replication has to be the exact copying of over 3 billion nucleotides and each second, our body makes over 100,000 mistakes. Most of them are averted but some of them turn out to be bad. These mutated cells, call mutiny over the body. They are rogue cells. The body behaves diplomatically and stimulates signals to tell these rogue cells to stop growing, but they ignore these signals and continue growing. In fact, they stimulate the body to give them their own supply of blood, this provides them with their own supply of nutrients. The mutated cells can potentially grow forever. Technically, they are ... Immortal.



Current treatments for cancer include surgery - cutting the body open at the location of the tumour, then surgically removing the tumour; radiation therapy - where high doses of radiation kill the cancer cells and shrink the tumour; chemotherapy - using drugs with a great number of side effects and also a great amount of pain, to kill cancer cells; targeted therapy - it targets the changes in the cancer cells that help them grow, divide and spread; hormone therapy - slows down and sometimes stops the growth of cancer that uses bodily hormones to grow; immunotherapy - a procedure involving usage of drugs to help make the immune system stronger and help fight off the cancer by increasing stimuli inducing chemicals that put a stop to the growth of cancer and then a second dose to completely kill off

the tumour; and stem cell transplant - a procedure that restores blood forming stem cells to fill in for the blood lost to cancer and other cancer treatments like chemotherapy. But all of these methods have grave side effects.

Surgery ensures direct contact with the tumour, this means that the surgeon cuts through multiple layers of healthy tissue to get to the tumour. This process is painful, if not during (because of general anaesthesia), definitely after, as these cuts take a long time to heal. Many surgeries can't remove the entire tumour, so

the surgeons debulk it, because removing a major chunk of tumour could also lead to healthy tissue damage. Also, it has to be remembered that surgery is not a definitive cure because cancer exists at the cellular level and spreads throughout the body, hence there can be remnants which relapses after the procedure is over - months or even a few years after. Infection is another problem that can happen after surgery, because a part of the body was opened and traumatised, this compromises the immune system and gives way to various infections. Other risks of surgery include bleeding, damage to nearby tissues, and reactions to the anaesthesia.

Radiation therapy are of two types, external beams and internal radiation (brachytherapy). An external source shoots beams of radiation at you, or a radioactive source (solid or liquid) is passed through the blood stream through an IV line. But even this therapy has threatening drawbacks. Radiation affects not just the cancer cells, but also the healthy cells surrounding it. But the worst effect is the fatigue after the therapy. It is immense and long lasting. Healthy cells that are damaged during radiation treatment almost always recover after it is over. But sometimes people may have side effects that are severe or do not improve. Other side effects may show up months or years after radiation therapy is over. These are called late effects.

Chemotherapy works by stopping or slowing the growth of cancer cells, which grow and divide quickly by using strong drugs. Chemotherapy not only kills fast-growing cancer cells, but also kills or slows the growth of healthy cells that grow and divide quickly. Examples are cells that line your mouth and intestines and those that cause your hair to grow. Damage to healthy cells may cause side effects, such as mouth sores, nausea, hair loss and problems in digestion.



Immunotherapy is a type of cancer treatment that helps your immune system fight cancer. The immune system helps your body fight infections and other diseases. It is made up of white blood cells and organs and tissues of the lymph system. Immunotherapy is a type of biological therapy. Biological therapy is a type of treatment that uses substances made from living organisms to treat cancer. But the list of side effects caused by this therapy outweighs its organicity. They include: pain, swelling, soreness, redness, itchiness, rash, fever, chills, weakness, and the list goes on.

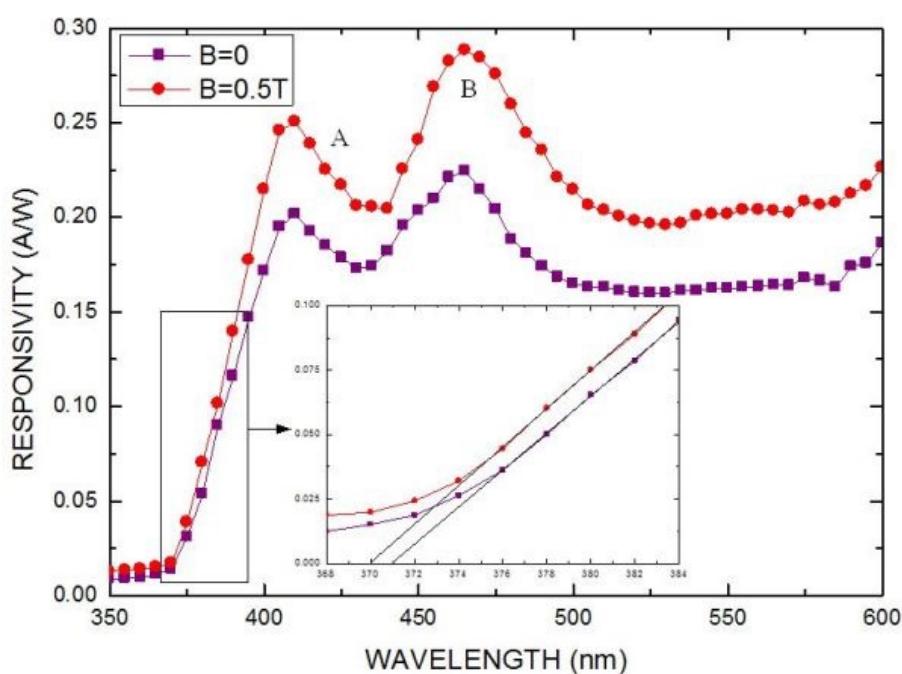
Targeted therapy uses precision medicine to cause effects that lead to a fighting chance against cancer. Precision medicine refers to the use of information about the genes, proteins, and other features of a person's cancer to diagnose or treat

their disease. However there are drawbacks. Cancer cells can become resistant to the therapy. Also, drugs for some targets are hard to develop. Reasons include the target's structure, the target's function in the cell, or both.

Hormone therapy involves usage of hormones, therefore many bodily functions are altered. Some side effects include a sudden rise in body temperature, inability to have sexual intercourse, weak bones, diarrhoea, nausea and most of all, fatigue. Similarly, stem cell transplant also has side effects like excessive bleeding and higher risk of infection. The most common infection during a stem cell transplant is the graft vs host disease, where the donors blood identifies the hosts blood as foreign and starts attacking it; this cause serious damage to the kidneys, liver and the intestines.

One of the major reasons for development of cancer is exposure to radiation. Radiation isn't that uncommon anymore, it's emitted from things all around us. Even if you stay hidden from all artificial objects, there is one large source of radiation which is just impossible to escape - the Sun. It gives off harmful ultra-violet (UV) radiation; the Earth's ozone layer blocks out quite a lot of it, but recent inhumane activities such as the over use and abuse of fossil fuels and CFC emissions has caused the layer to deplete and radiation levels to spike. The radiation can cause hydrogen bonds between two chains to break. Hydrogen is the basic, fundamental element the entire universe is made of and so are we. This causes alterations in the genome, it disfigures it and then leads to abnormal growth - cancer. Before we learn how to cure cancer, the first step should be to prevent it. And to start off with this major source, using nanotechnology in sunscreens is vital. Zinc oxide is known to absorb UV radiation through a process of electron excitation called band-gap absorption and turns it into comparably harmless infrared, which it disposes of as heat. The chart below shows how the band gap of zinc oxide allows

the wavelength of UV rays (100-400 nm) to cause the photoelectric effect.



Sunscreens are used to provide protection against adverse effects of ultraviolet UVB (290–320 nm) and UVA (320–400 nm) radiation. According to the United States Food and Drug Administration, the protection against UVA should be at least one-third of the overall sun protection factor.

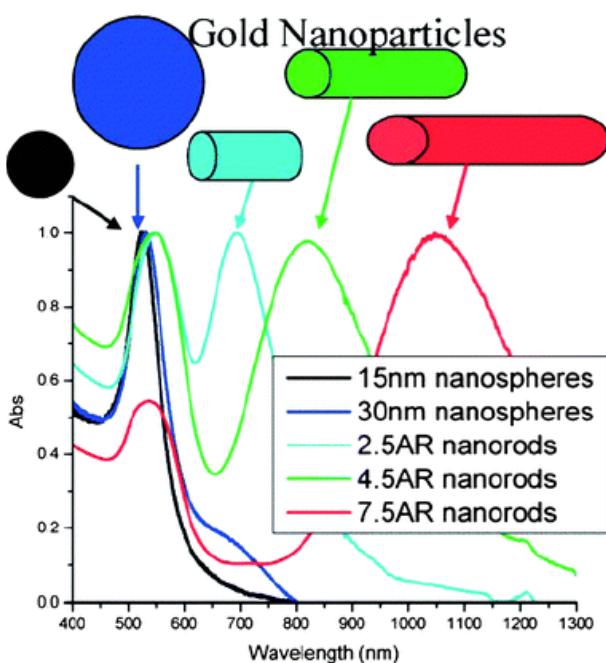
Titanium dioxide (TiO_2) and zinc oxide (ZnO) minerals are usually put in sunscreens as inorganic sun blockers. As TiO_2 is more effective in the UVB range and ZnO in the UVA range, the combination of these particles assures a broad-band UV protection. However, to solve the cosmetic drawback of these opaque sunscreens, micro sized TiO_2 and ZnO have been increasingly replaced by TiO_2 and ZnO nanoparticles ($<100\text{ nm}$). This review focuses on significant effects on the UV attenuation of sunscreens when micro sized TiO_2 and ZnO particles are replaced by nano particles and evaluates physicochemical aspects that affect the effectiveness and safety of nano particle sunscreens. With the use of TiO_2 and ZnO nano particles, the undesired opaqueness disappears but the required balance between UVA and UVB protection can be altered, however using a mixture of the two is a solution to the problem. ZnO and TiO_2 nanoparticles have revolutionised cancer prevention methods due to the UV radiation. Their economic rate has also made them viable for mass production and distribution. Almost all sun screens now have a mixture of the two nanoparticles.

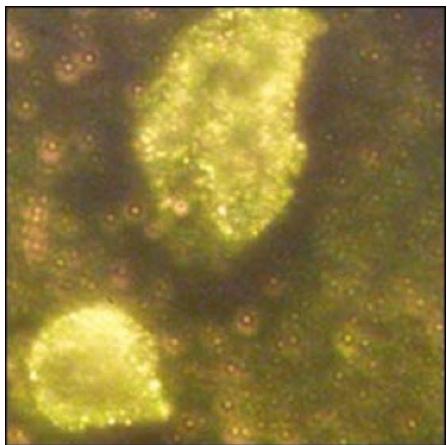
Even with strong prevention steps, sometimes cancers form, therefore detecting the tumour becomes the next crucial step. Gold nanoparticles have been extensively used in biomedical applications owing to their biocompatibility, simplistic synthesising methods, easy surface functional qualities and tuneable physical properties. Their sizes and shapes can be varied for various biological applications. The change in the size and shape of these nanoparticles affects their absorption rate that can vary in the visible spectrum (visible IR range). The colour of the nanoparticles also changes depending on

the absorption rate due to the size decrease as it affects the wavelength. Gold nano particles are red, in contrast to the golden yellow we normally see. This tune ability of optical absorption makes it useful for various biomedical applications including, colorimetric detection assays for proteins, cancer cells that operate in the visible range; photo thermal therapy, and heat-induced drug delivery that operate in the near infrared range.

Nanoparticles that have significant absorption in the tissue optical window (600–1300 nm), which is also known as near infrared, are promising to sense and detect tumours and also act as therapeutical agents for cancer cell treatments, because healthy tissue cells do not absorb light in this spectral region. Moreover, in longer wavelengths the scattering of the light is minimised.

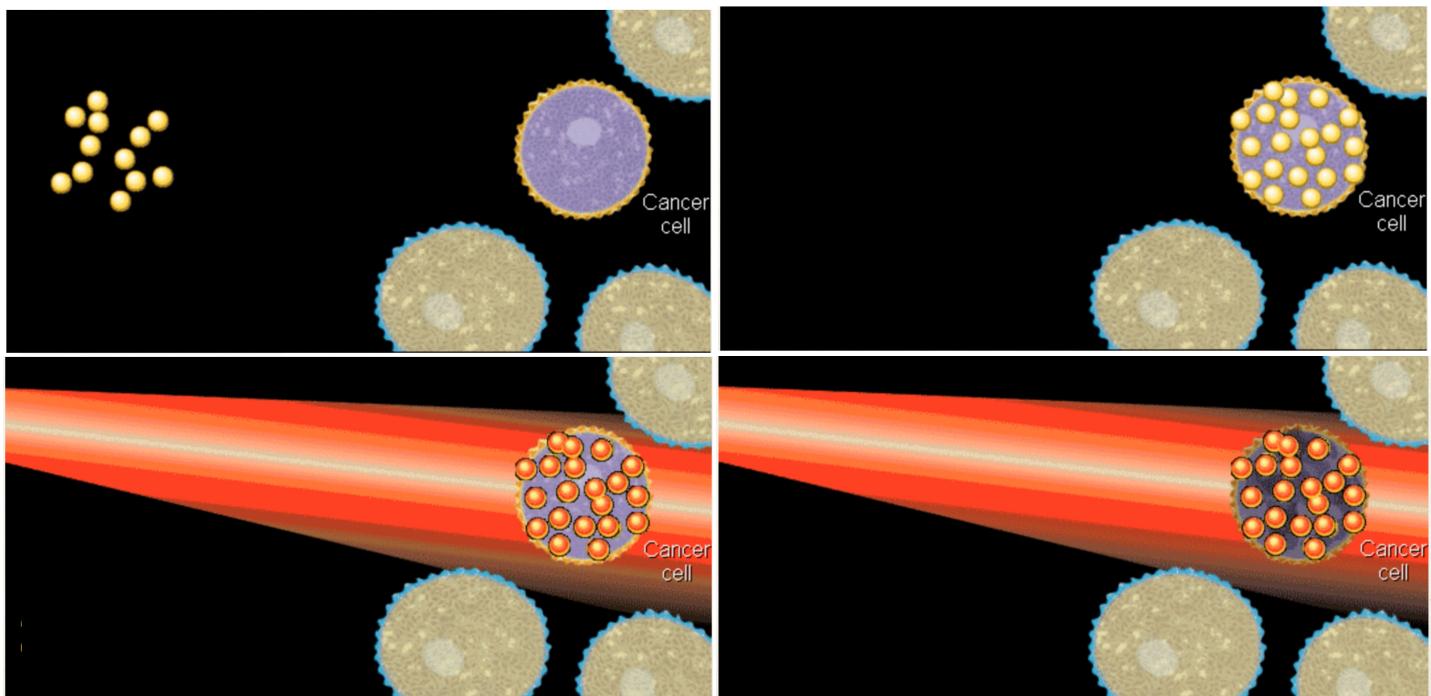
Thus, the combination of the minimal scattering and near infrared absorption allows deep tissue penetration. This penetration depth can be 1–10 cm depending on the location and type of the tissue. The rod shape is preferred over the spherical one because of its absorption rate. The graph compares different nano shapes and shows how longer nano rods absorb more and become clearer as their wavelength increases.





The nano rods are coated with antigens that make it bind to the amine and thiol groups. Cancer is a protein so the antigen-antibody acts like a lock and key function so the nano particles stick right onto the tumour which can then be treated using infrared. It looks like the figure at the right. Gold nano rods stick only onto the cancer cells (bright yellow regions) leaving healthy cells the way they are (dark regions). After the cancer is detected, killing those cells becomes the next objective. Nanotechnology is the answer to this problem too because at the cellular levels, only cellular sized (nano particles are even smaller) weapons work.

Once the tumour is detected, silica based nano shells loaded with molecules of light sensitive drugs are transported to the cancer cells. They are coated with the same antibody that the gold nano rod was coated with so that it only sticks to the cancer cells. Light is then supplied to this region and the drugs are released as the silica dissolves due to the light sensitive heated up drugs inside it, which are then released that combat the cancer. The drugs produce reactive oxygen molecules which kill the cancer cells.



My theory

As mentioned earlier, cell division involves the exact copying of three billion nucleotides. Each second, our body makes over 100,000 mistakes, but most of them are rectified. If we can extract the cells and analyse its nucleotides, the DNA in it through chromatography, a procedure that already exists and is used for DNA sequencing. What if we could identify the missing link, the error, the fault in copying? The amino acid that was faulty? It's 3 billion nucleotides, so it might be a long shot running all of them through and comparing them to the original cell but technology to do this already exists. Why can't hospitals or laboratories be equipped with super computers? They could analyse it in a fraction of a second. Once identified, using (fairly large) silica nano spheres loaded with two

other nano spheres. One (let's call it RK0) that will penetrate into the cancer cell and one(let's call this one RK1) with that specific order of amino acids could be transported to the cancer cell and then. Penetrating might be a problem as incision tools aren't made at the nano scale but coating the nano sphere with the light sensitive drug that undergoes the photo thermal effect could solve that. If the RK0 (which is much smaller than the cancer cell) could melt or burn its way through the cell, like a blowtorch, it could get inside and dissolve. Next, RK1 is transported inside the cell through the cavity created by RK0 and then is loaded with a chemical that sticks only to the area with the fault. Providing RK1 with light will dissolve its outer shell and the amino acids will fall right into place making the tumour harmless, intact just another body part.

This leads to another idea. Cancer is practically immortal. Why not make use of this factor? If we do master genetic engineering in the near future, recreating cells, any cell at all could be possible. If the liver is damaged, giving it cancer will cause a tumour of faulty cells to form. If we could make these cells not faulty using the method mentioned above, we could recreate any organ at all. This could revolutionise the use of nanotechnology in biomedical applications. It could, theoretically, lead to immortality. Making use of the fact that cancer cells grow and divide forever and manipulate it towards our own use can make us live forever. There will come a day when people will say that there used to be a time when we died of cancer and now we live because of it. Like it says in the title, if the bad guys were good, if all the criminal masterminds used their genius for good, it will make the world a better place.