local secondary radiation, which delivers its energy locally, so inside the tumor. [**?**] The reason gold is used instead of other element with high atomic mass, is that gold biocompatible, which makes it suitable for medical treatment. [**?**]
The first experimental evidence of the use of GNP to enhance radiation therapy was provided by Hainfeld et al. [**?**]. Mice with cancer tumors were injected with 1.9 nm diameter GNP and then radiated with 250 kVp X-rays. The combination of GNP and radiation resulted in a one-year survival of 86% compared to 20% with radiation therapy alone. Other experiments showed similar evidence of the radiosensitizing effect of GNP. !REFERENTIES! These results provide a motivation for further research within the field of nanoparticle enhanced radiation therapy.
The main goal of this project is to synthesize GNP of different sizes and to characterize them using different methods. Next the GNP are functionalized with a polyethylene glycol (PEG) coating, which provides stability to the GNP solution, i.e., prevents them from aggregating. The PEG coating also increases the probability of delivering the nanoparticles to the cancer cells. Finally a mixture of DNA and GNP is irradiated and the effect on the DNA is analysed.

2 Theoretical background

2.1 Radiation physics

Opzoeken gebruikte straling bij radiation therapy A. Zuppinger. Particle Beam Therapy. Proceedings of the Royal Society of Medicine, 58(March):151160, 1965.
There are three possible ways photons can interact with matter: photoelectric absorption, Compton scattering and pair production. In the photoelectric effect, the energy of an incoming photon is transferred to an electron, which is then ejected. The vacancy left by this electron is then filled with another electron from a higher shell. This electron then gives of its excess energy as an characteristic X-ray photon. In some cases the excess energy may be transferred to an outer-shell electron. As a consequence this electron is ejected and is called an Auger electron. The cross section for photoelectric absorption τ increases for increasing mass number Z and in decreases sharply with the photon energy E_γ: Formule

$$\tau C^{te} \cdot \frac{Z^n}{{E_\gamma}^3.5} \tag{1}$$

with n varying between 4 and 5.
The Compton effect is an inelastic scattering between a photon and an electron, where part of the energy of the incoming photon is transferred to the recoiling electron. The cross section for Compton scattering grows linearly with Z and falls of gradually with increasing energy. With pair production, a photon creates an electron-positron pair. The cross section for this process varies approximately with Z^2 and increases for increasing energy.
Since the cross sections for each of these processes increases with increasing Z, it is clear that gold, with its high atomic mass, is suitable for radiosensitization.

2.2 Biological effects

2.3 Targeting

In order to have a beneficial effect of GNP in radiation therapy, it is important to bring the nanoparticles as close as possible to the DNA of the cancer cells. The uptake of GNP into the nucleus of the cells is only possible below a certain upper size limit.
http://onlinelibrary.wiley.com/doi/10.1002/smll.201000134/full Therefore the size of the nanoparticle is a very important parameter. GNP are known to passively accumulate in cancer cells because of the enhanced permeability and retention (EPR) effect. Because cancer cells are rapid growing cells, tumors have leaky, immature vasculature, so that their blood vessels are more permeable.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3473940/ This effect can be enhanced by functionalizing the naked gold nanoparticles with PEG. This PEG coating sterically hinders nonspecific binding of proteins to the surface of the particle and delays the recognition of the particles by the reticuloendothelial system. This increase the circulation time of the GNP in the blood and as a