



Investigating the Role of Magnetic Hyperthermia in Cancer Treatment

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Introduction

- Last year's topic
- Magnetic hyperthermia - experimental treatment for cancer
- Magnetotactic Bacteria(MTB) and Magnetic nanoparticles(MNP)

Introduction

- MTB- bacteria that align to Earth's magnetic field
- MTB comes in many different forms
 - Average size is 35-120 nm
- MTB is collected in aquatic environments

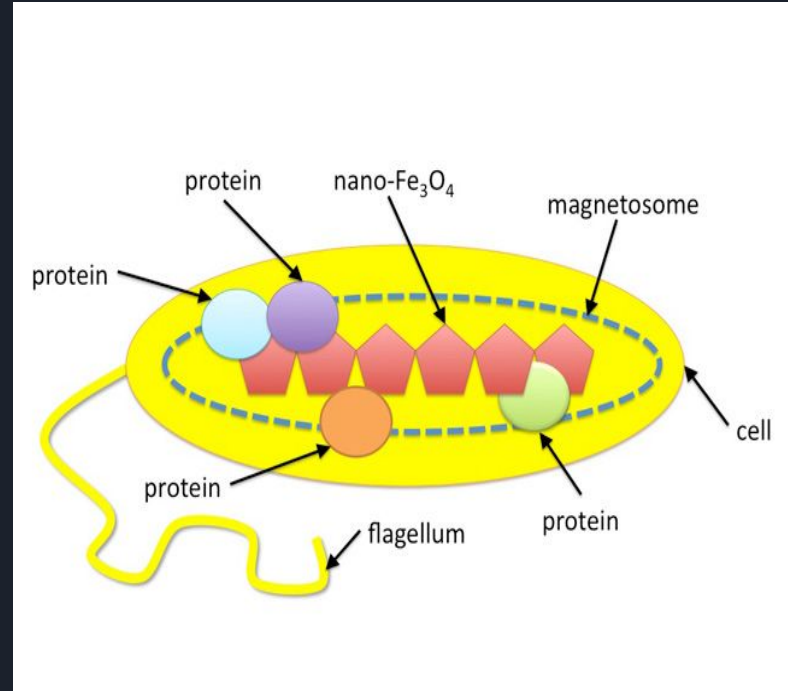


Figure 1. Basic structure of magnetotactic bacteria.

Introduction

- MNPs - nanoparticles controlled by magnetic field
 - Measure 50-200 nm
 - Benefits over MTB:
 - More compatible with antibodies
 - Inductive heating properties

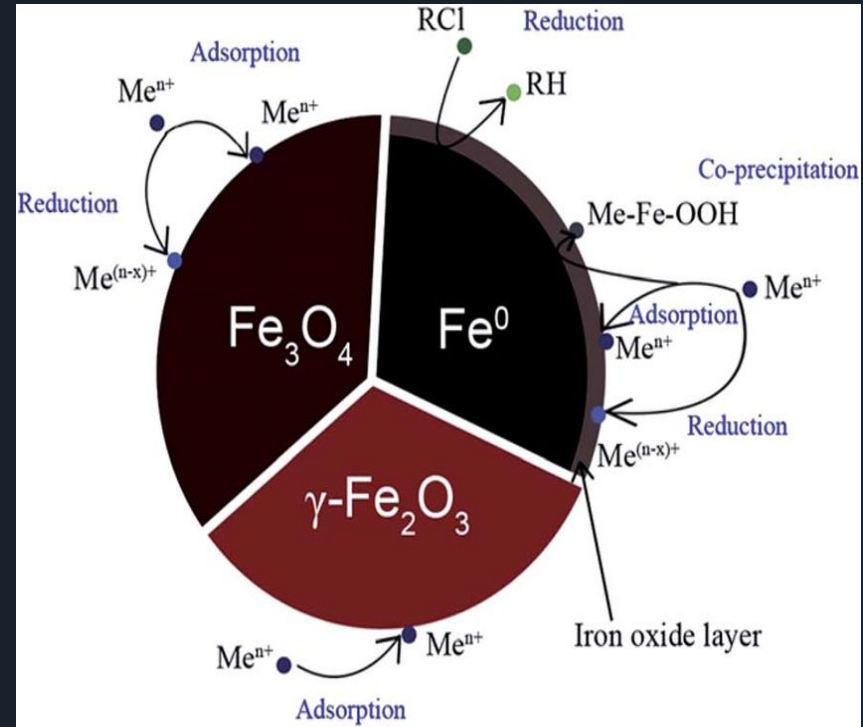


Fig 2. Basic structure of a magnetic nanoparticle (MNP).

Introduction

- Magnetic hyperthermia:
 - Employs the use of AMF
 - MNPs convert energy to heat
 - MNPs favored in research
 - Treats various diseases
 - *S. Aureus*, Osteosarcoma

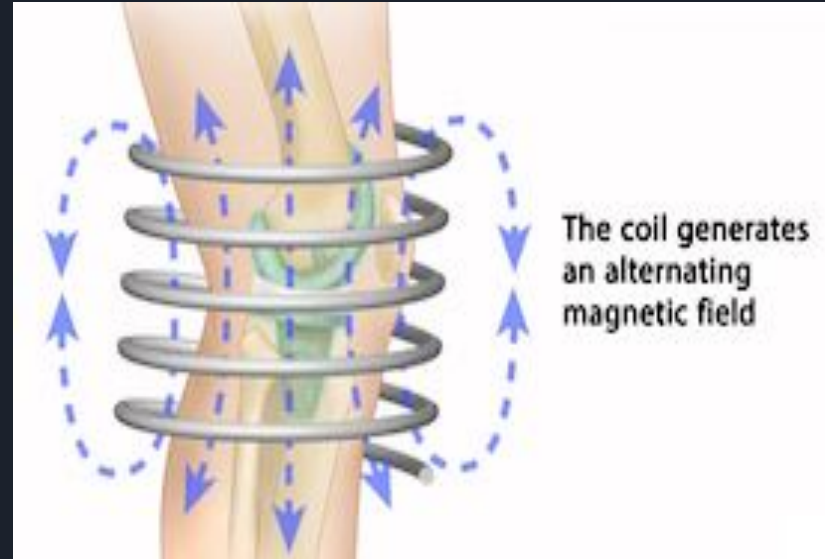


Fig 3. Application of AMF in order to control MNPs or MTB within the body.

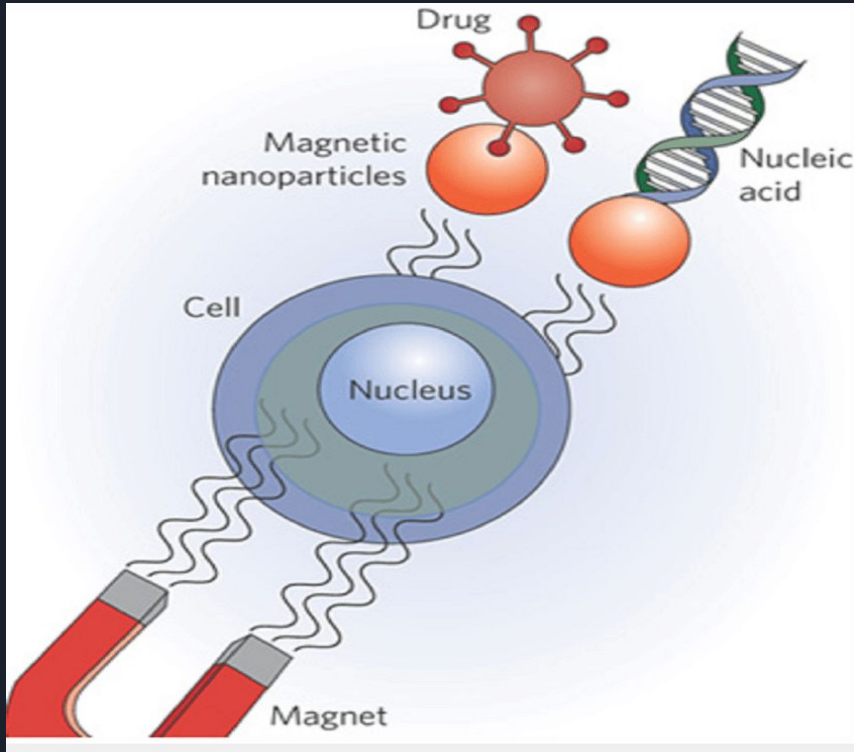


Fig. 4 Basic application of magnetic nanoparticle in order to treat a neurological cancer (brain tumor)



Purpose

- Cancer- one of the leading causes of death
- Chemotherapy and radiotherapy are both temporary
- Magnetic hyperthermia main point is to amplify
chemotherapy

Research Question

Is magnetic hyperthermia viable in cancer treatments and what is the optimal temperature for it to be applied?

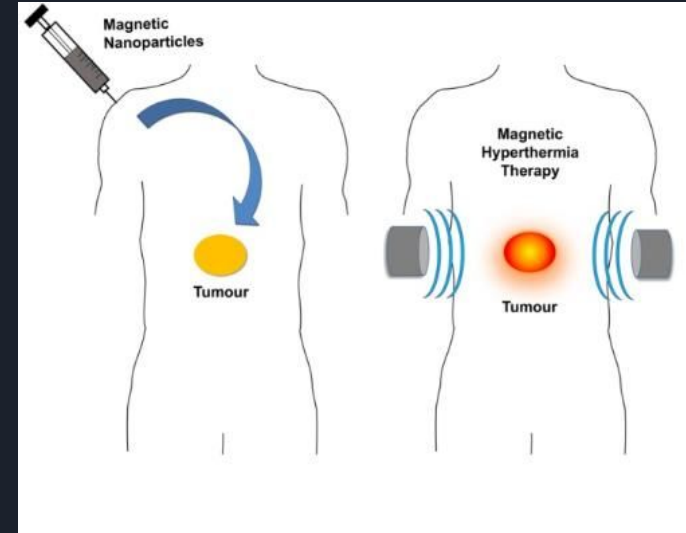


Fig 5. Shows injection of MNPs into the body which are directed to the tumor. Then, the AMF is used in order to conduct the treatment



Hypotheses

Alternative: Magnetic hyperthermia with MNPs is effective in cancer treatment and the optimal temperature is 42-44 degrees Celsius.

Null: Magnetic hyperthermia is not effective in cancer treatment and the optimal temperature is above or below 42-44 degrees Celsius.



Methods

Scientific Literature Review

- Build a solid understanding of the benefits and limitations of magnetic hyperthermia by using:
 - Ebscohost
 - PubMed
 - PLOS One
 - NIH
 - Research Gate
 - NCBI



Methods

- Extract, combine, and compare data
- Used data collected and analyzed
 - Statistical analysis test (t-test)
 - Peer-reviewed papers



Results

- Successful in vivo experiments
 - Mice
 - Hamsters
 - Rats

- No data for the results from human clinical trials
 - Magnetic hyperthermia




Table 1. This table shows the effect of various temperatures on cancer cells. The following data represents the % living cancer cells after the treatment in Chinese hamster ovaries (Sources 1,2).

Temperature (degrees Celsius)	% cancer cells survived
41.5	50
42	10
42.5	.01
43.5	.02
44	.06
45.5	.06



Discussion

- The ideal temperature = 42.5°C-43.5°C
- Less than .05% cancer cells survived in ovaries
- 44°C & 45.5°C were also effective, not efficient

Table 2. Data comparison showing the results from different studies in which MHT was applied to F344 mice that were injected with glioblastoma cells (Sources 3, 4, 5, 6, 7, 8).

Temperature Reached (degrees Celsius)	Duration of AMF exposure (min)	Results
43	60	Complete glioma cell death
43-44	30	Necrotic tumor cells, some animals displayed complete tumor regression
43-44	30	Some animals displayed complete tumor regression
43-44	30	Some animals displayed complete tumor regression
42	30	Reduced tumor growth
44.4	30	Significant tumor cell death
45	40	Necrotic tumor tissue



Discussion

- Tumor growth was stopped, reduced, or tumor cells became necrotic
- Temperature of 43°C actually killed all glioma cells
- Different studies, same temperatures, similar results
- Most effective results at 42-44 °C

Radiation/Chemotherapy Alone vs. Radiation/Chemotherapy with Traditional Hyperthermia

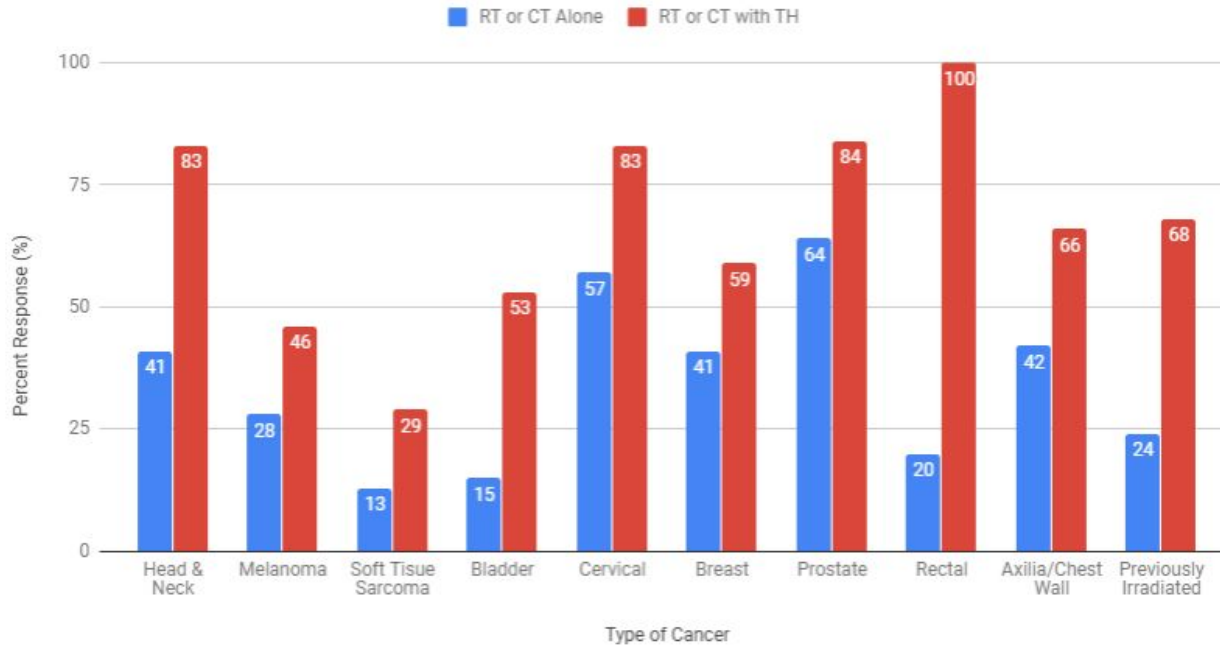


Fig 7. This bar graph shows the treatment results in humans for traditional hyperthermia in different types of cancer. Percent response is the number of patients that were recorded to have a decreased tumor size (Sources 9, 10, 11, 12, 13, 14, 15, 16, 17).



Statistical analysis of Fig 7.

- Conducted one-tailed, assuming unequal variances t-test
- RT/CT Alone: Mean-34.5, StDev-17.39
- RT/CT with TH: Mean-67.1, StDev-21.18
- P-value = 7.54×10^{-4} , Reject Null Hypothesis
- Treatment with TH is statistically significantly better
- By definition MH is more controllable
 - Even better results than TH



Limitations

- Difference in temperatures tested
- Toxicity in MTB and MNPs cause side effects
 - Prevents human clinical trials- causes lack of data and research
- Magnetic hyperthermia- still theoretical



Conclusion

- Magnetic hyperthermia has been successful in vivo
 - Possibly be implemented in humans
- Optimal temperatures for further studies
 - 42-44°C
- MNPs and MH could potentially completely treat cancer
 - Further work still necessary



Further Work

- Clinical trials will continue to be done in vitro and in vivo
 - Possibility of human cancer treatment
- MNPs are being made more compatible with the actual antibodies



Reflections

- Coming up with topic from last year was better
- Narrowed down using mentor
- Conclusions were made by statistical analysis



Acknowledgements

I would like to thank the following people for helping me conduct my research and thoroughly understand my topic:

- Dr. Ian Baker
- Dr. Elio Perigo
- Dr. Paul Pagano
- Dr. Nikki Malhotra



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