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Laidlaw Research Proposal 2021:
To find which thermoelectric materials have the most promise for powering biomedical electronics using body heat.

Introduction and Background:

With the depletion of fossil fuels and the serious global warming crisis, finding innovative approaches to generate renewable energy is undoubtedly important. One such approach involves thermoelectric materials. Using a concept that has been applied in space exploration for years, we can exploit an exceptional property of these materials to power electrical devices using our very own body heat.

Thermoelectric materials that can convert waste heat (in this case body heat) into electricity. I want to research which materials have the most potential to be applied in the medical field. From biosensors to pacemakers and from cochlear implants to muscle stimulation, modern medicine relies on electronic devices for treatment and monitoring. Thermoelectric materials can revolutionise this sector. Where the current technologies rely on batteries and wires to operate, thermoelectric generators can provide power indefinitely just from body heat. It would also facilitate continuous data transmission (if the devices were connected to a wireless network) for remote patient monitoring. This would positively impact the efficiency of how medical teams can operate and improve the quality of treatment for patients. For example, it would take away the psychological and physical damage of having multiple surgeries to replace batteries of implanted devices, like pacemakers.

Summary:

Research will be done into what the most promising thermoelectric materials are for body heat-powered bioelectronics in medicine. Using thermoelectric material data from Manchester University and a simulation tool, the suitability of different materials to meet the device specific parameters, such as electrical and mechanical properties, will be analysed. To do this, research needs to be done into what the parameters of popular biomedical devices are as well as into the simulation tool. This will enable the tool to be used with an understanding of its advantages along with its limitations.

Not only does the material have to meet device specific requirements but research needs to be done into the fabrication process, the biocompatibility, the cost and the abundance of any candidate materials. All of these factors are significant because the motive behind the research is to find a more sustainable power source for bioelectronic devices, therefore the chosen material must not be detrimental to patients' health or the environment.

The summary of my findings will conclude the advantages and disadvantages of candidate materials that have shown promising properties to be used in thermoelectric generators for bioelectronics. From this critical thinking, an attempt will be made to predict the direction of thermoelectric materials and bioelectronics for the foreseeable future.

Aims and Objectives:

- to research what type of devices thermoelectric generators could power
- to analyse thermoelectric material data
- to simulate materials with device specific parameters
- to evaluate the process of fabricating the materials
- to discuss the environmental effects and biocompatibility of materials.

Methodology:

Week 1: Firstly, I will research what the common parameters of popular biomedical devices are. This will include researching the power needs of devices like biosensors or cochlear implants. From this information, I expect to find a range of device parameters that provide a basis of powering more than one bioelectronic device with a thermoelectric generator.

Week 2: With the design criteria established, I then expect to find thermoelectric materials that meet the criteria by using the simulation. An understanding of how the simulation works and how to use it must be consolidated first.

Week 3: I expect to have utilized the simulation and designed a thermoelectric generator with optimized geometry that can function over an interface (like skin). I will also log any comparisons the simulation makes to commercial generators.

Week 4: By then discussing the advantages and disadvantages of materials that met the requirements for powering the devices with body heat, I expect to research the physical properties of the materials themselves, the process of fabrication and the accessibility of the raw materials.This is an opportunity to weigh up any environmental pollution and cost against the current fabrication process for the biomedical devices of today.

Week 5: Research will be undertaken into the biocompatibility and hazards of candidate materials.This includes researching if there are any dangerous levels of toxicity, any allergy risks or even any radioactive decay that would be threatening to a patients' health.

Week 6: I expect to summarise the collated information and form an argument for and against each material. This will be presented in a poster or powerpoint presentation. After rigorous research into the field of thermoelectrics, my best output would be a proposed material that is viable to power bioelectronics with body heat.