

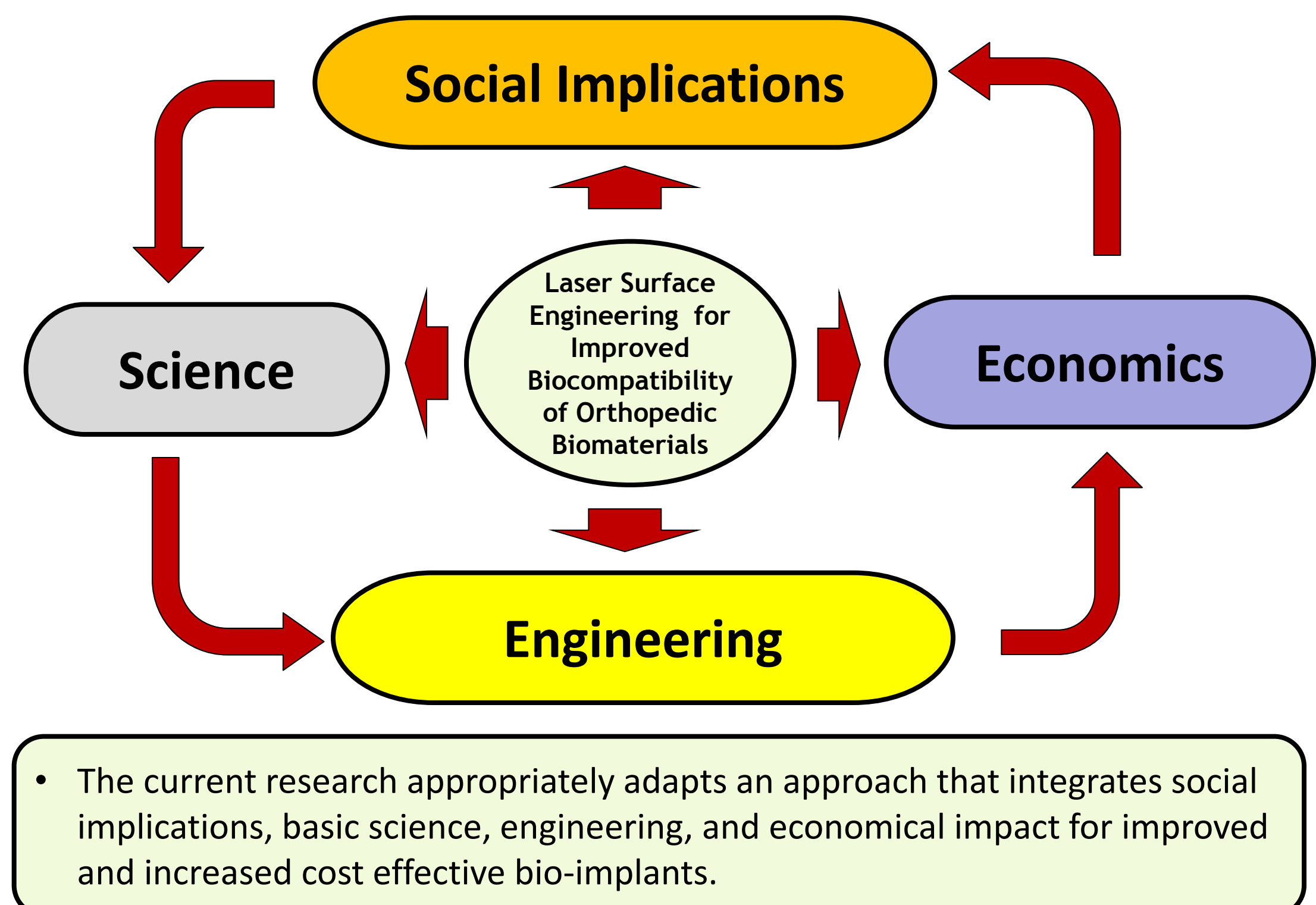


Laser Surface Engineering for Improved Biocompatibility of Orthopedic Biomaterials

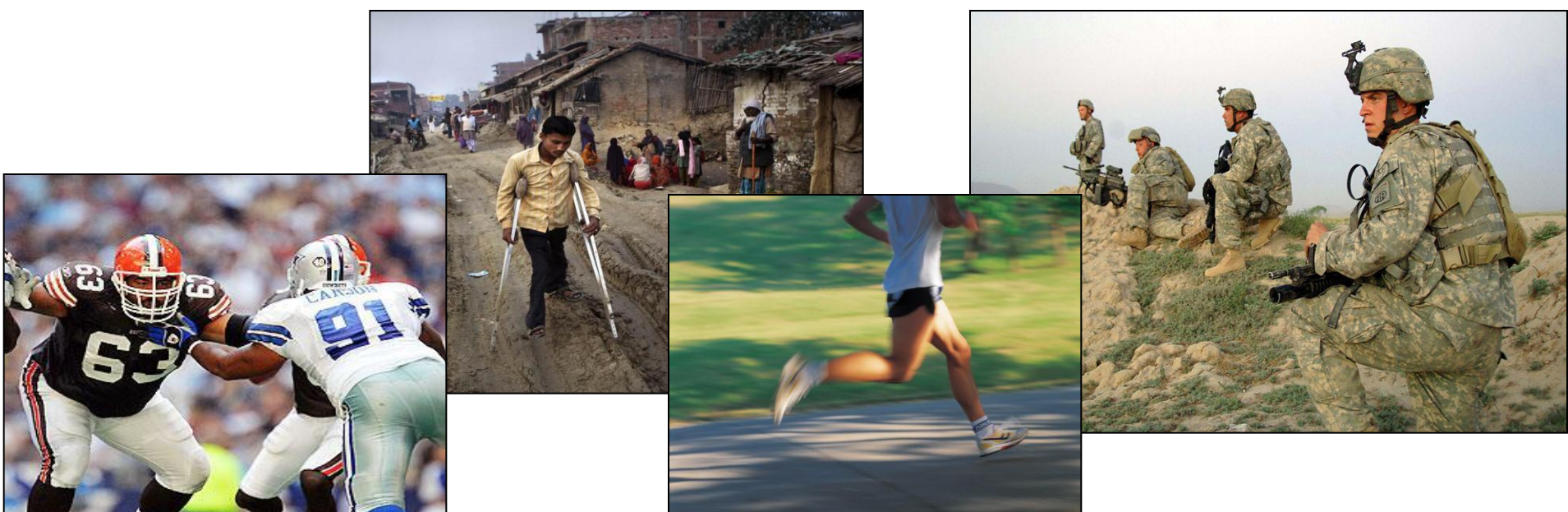
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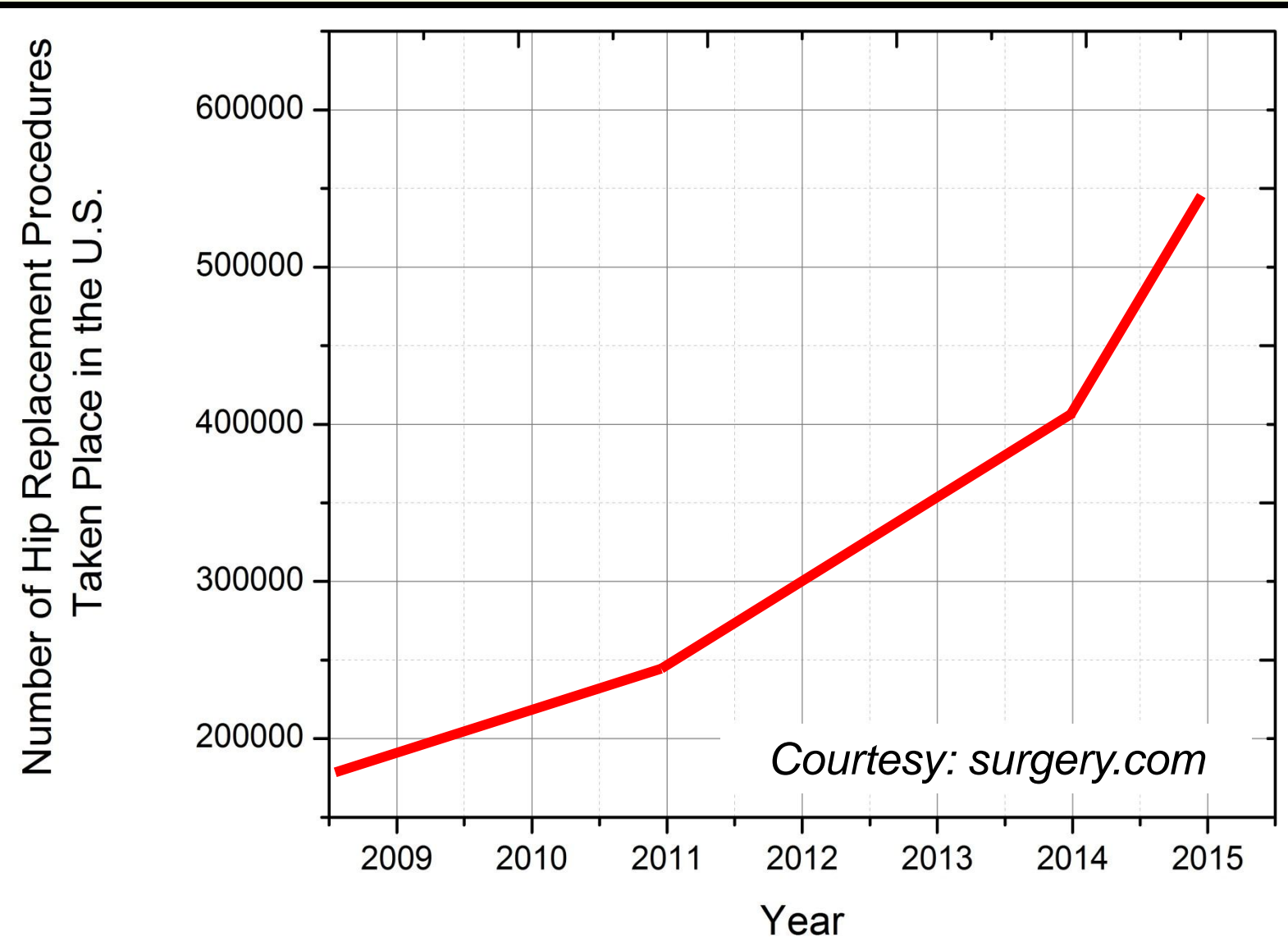
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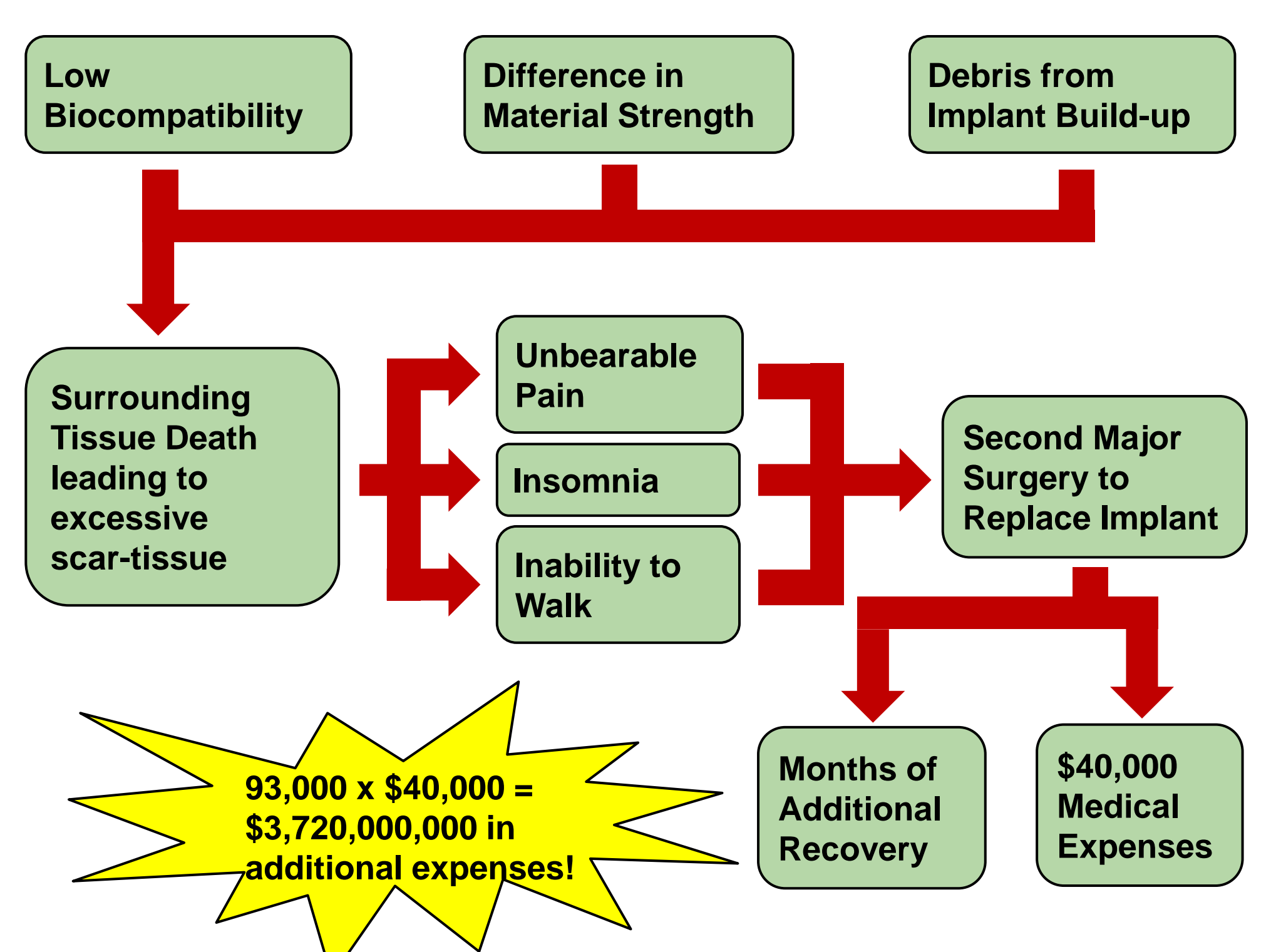
Social Implications



- Even now, 90% of humans above the age of 40 show signs of femoral bone degeneration resulting in a drastically increased number of replacement procedures being performed.
- Patients around the world are now requiring implants that can last longer and provide less discomfort, while decreasing the cost.



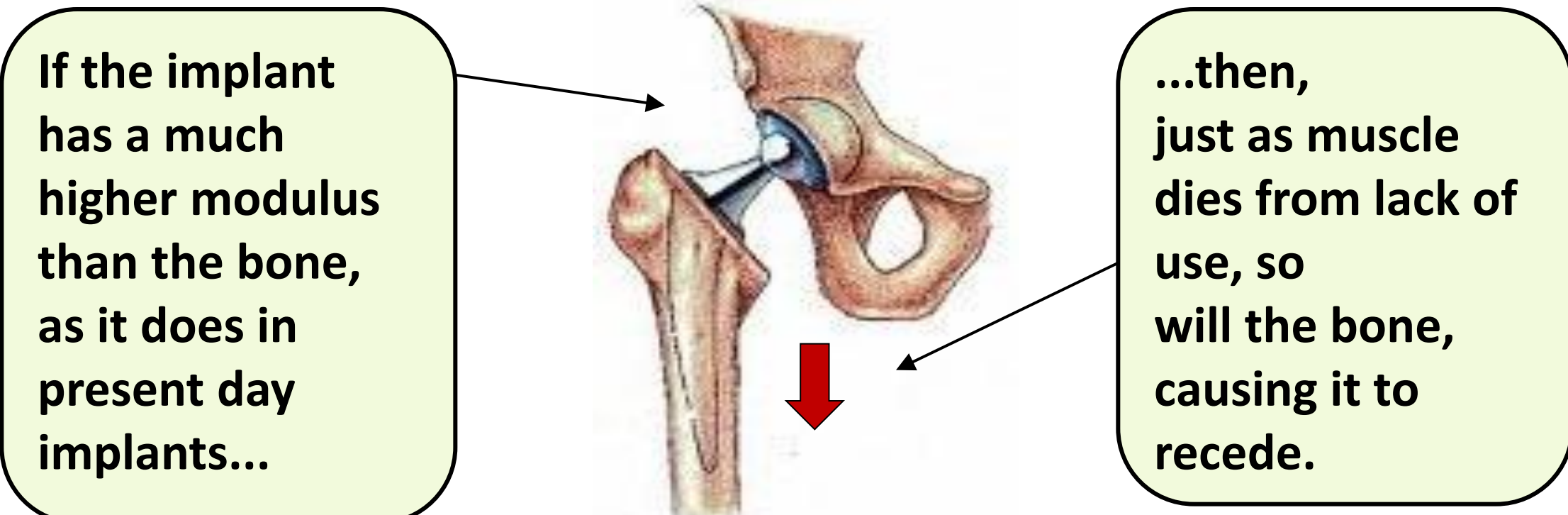
- There is an increased need of a longer lasting and more cost effective bio-implants for younger demographic



Basic Science

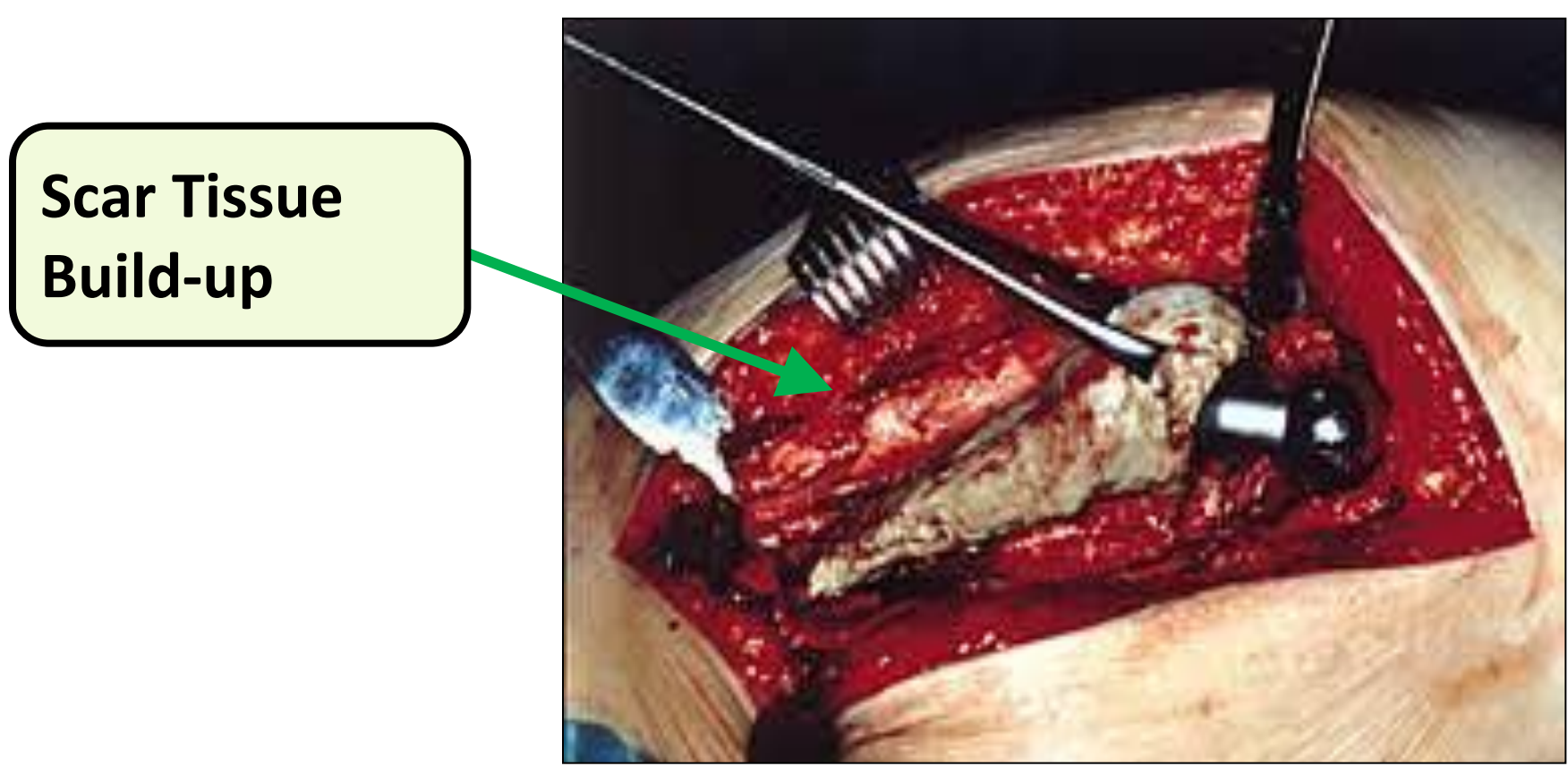
Titanium as a Bioimplant Material

- In order to create a more efficient bio-implant, a material must be modified so that it can be as similar to body environment conditions as possible. The implant must be interpreted by the body as just another piece of bone. Titanium is already being widely studied as base bio-material. Titanium has a modulus, or strength, similar to that of human bone allowing internal body conditions to stay as constant as possible after implantation.



Lack of Chemical Compatibility

- What titanium makes up for in strength, it unfortunately lacks in biocompatibility due to a lack of suitable chemistry. In the image below, scar tissue can clearly be seen building up around the implant. This leads to a second surgery to replace the implant.

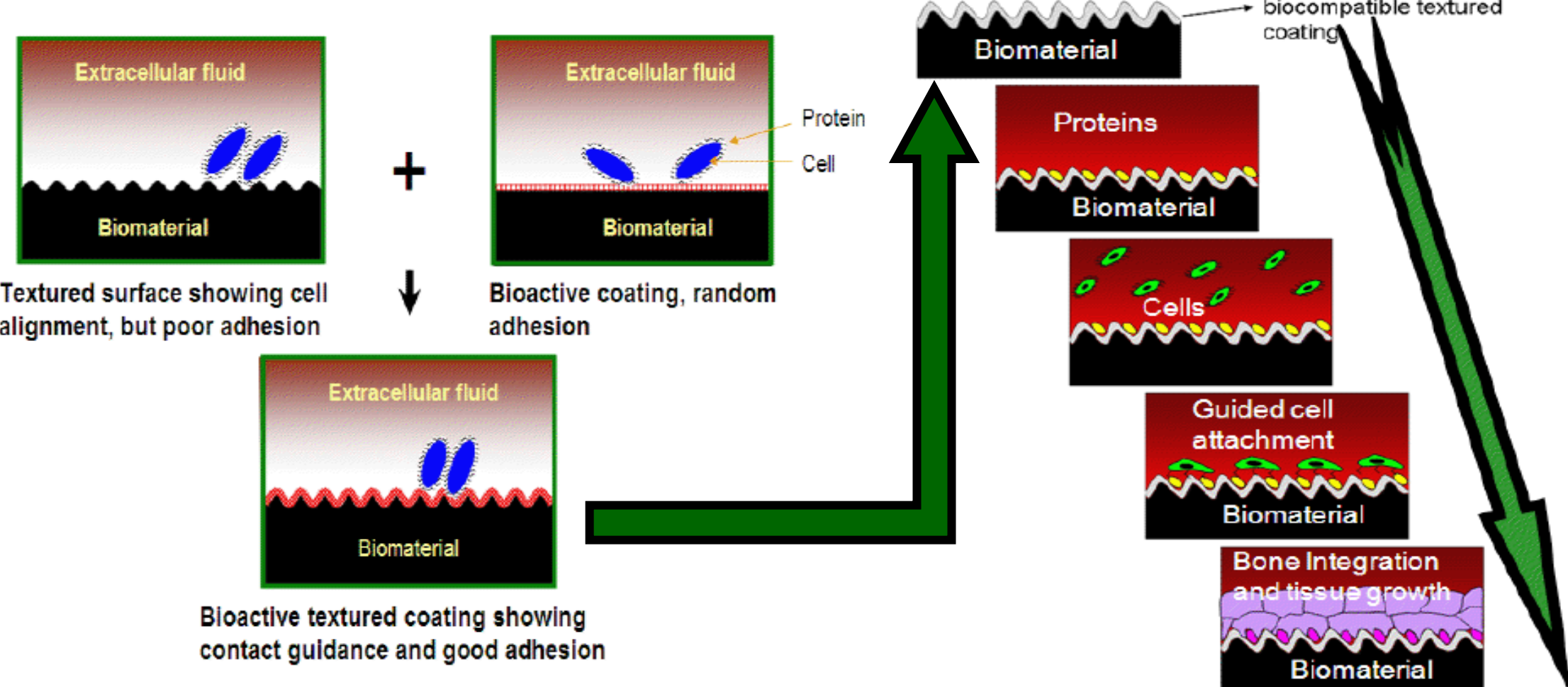


- The goal of this project was to find a way to increase the biocompatibility of titanium implants so as to increase the success of future implants.

Need for Chemistry & Texture for Biocompatibility

- Due to lack of chemistry, cells that should surround the implant are unable to attach to the metallic surface, preventing bone growth. This is due to two factors: cells not recognizing the foreign metal implant and a surface that cells are not capable of adhering to the implant surface due to a lack of texture.
- In order to address this, we are proposing synthesis of a textured calcium phosphate (major constituent of human bone) based coating on the implant surface, which is likely address both issues.

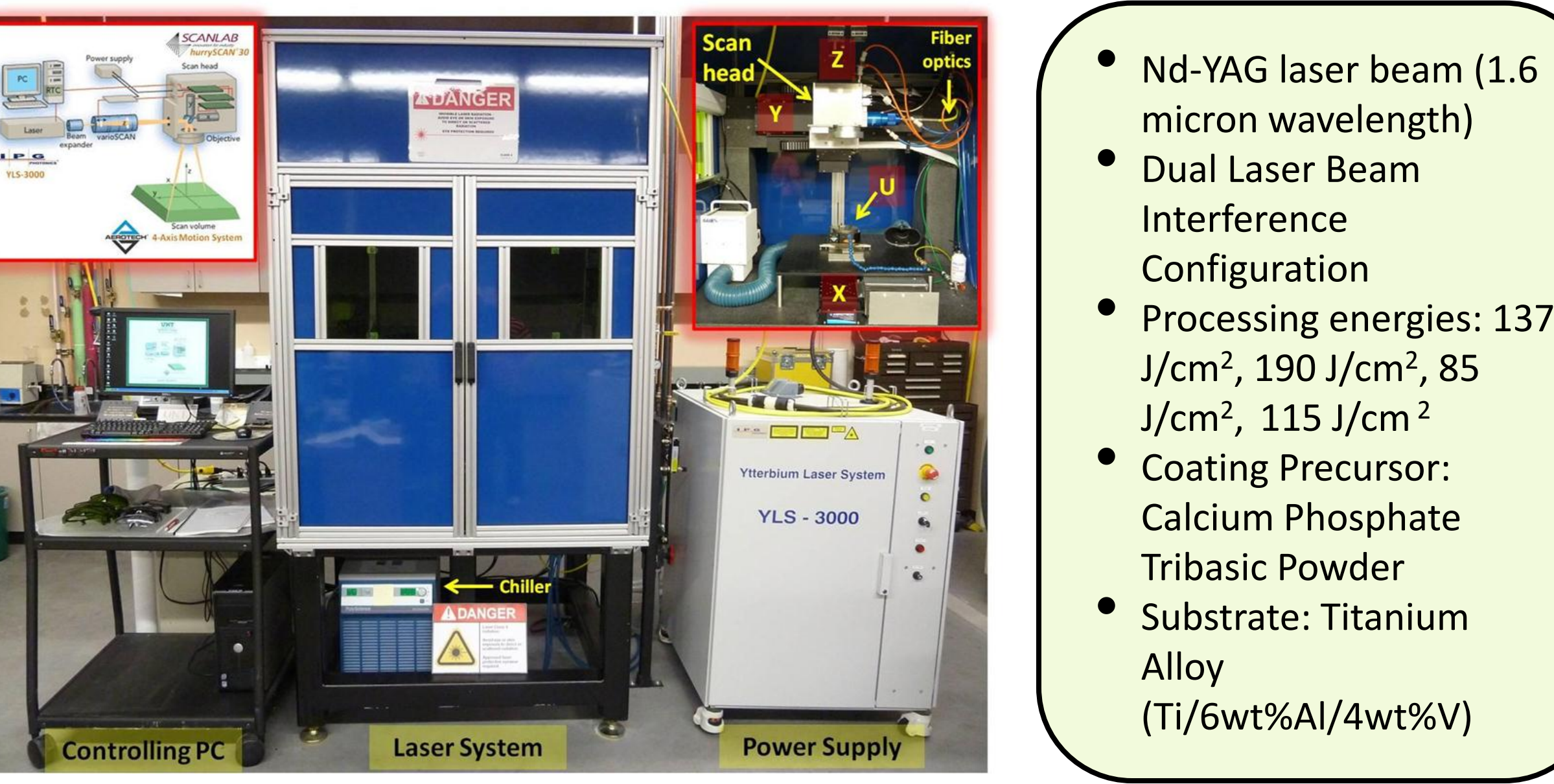
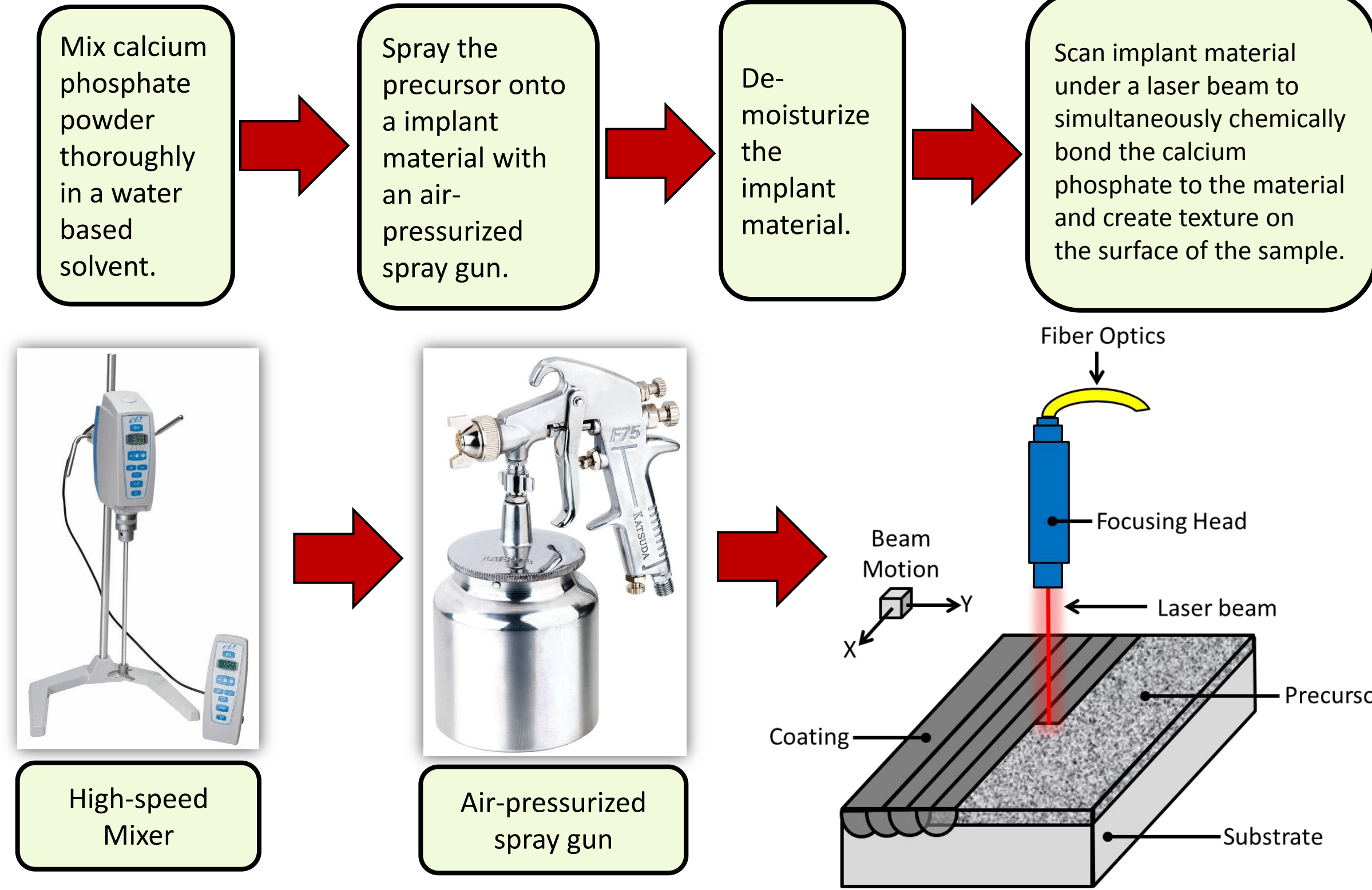
Rationale for Proposed Approach



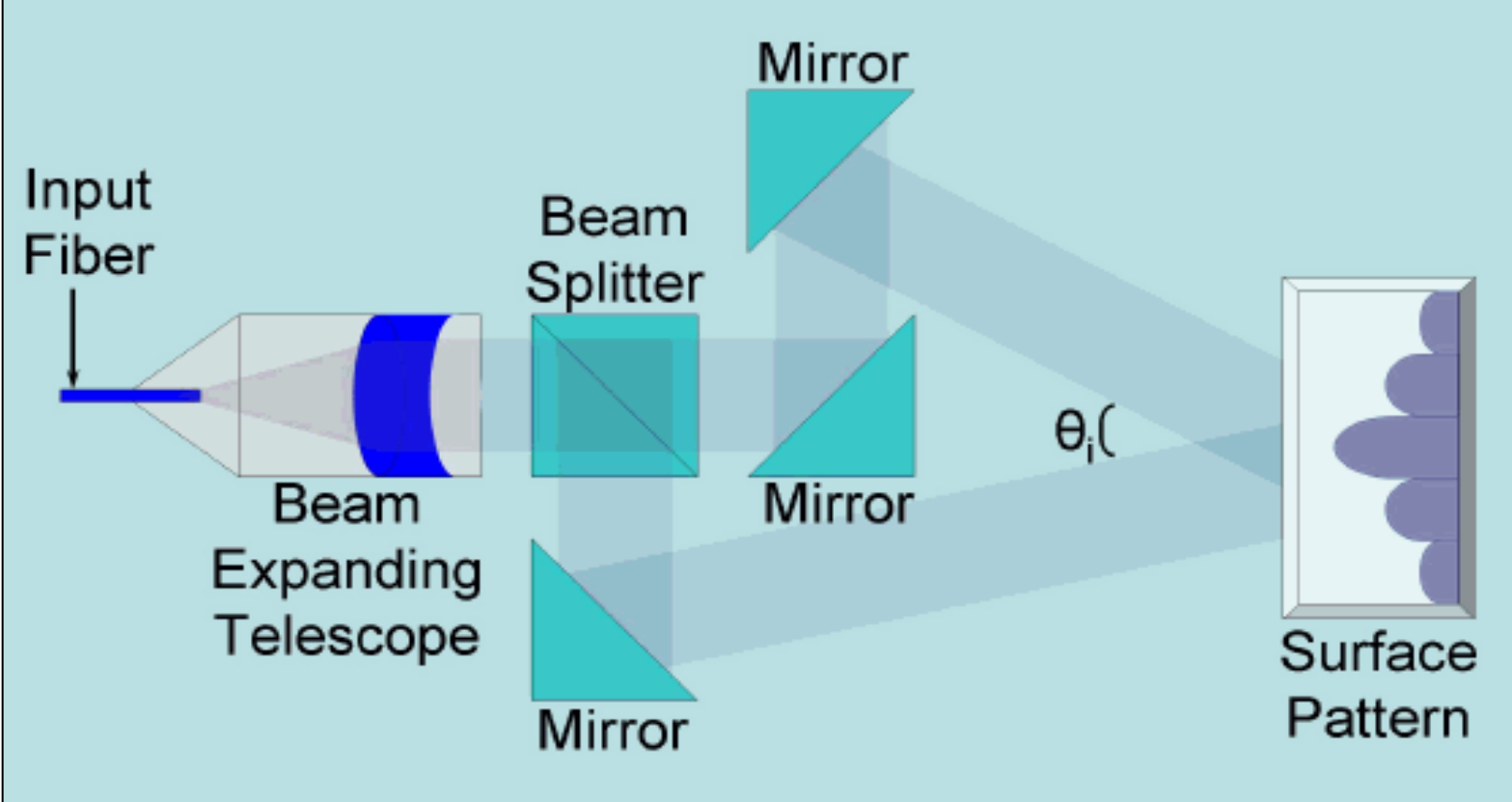
- A calcium phosphate coating was chosen because of its similarity to bone. Cells that surround the implant will recognize the implant as a piece of bone and attempt to adhere. But its not that simple. Just as we cannot attach ourselves to a smooth wall, cells cannot attach to the smooth surface of an implant. They require a microscale level of texture to which they can adhere onto.

Engineering

Engineering a Textured Coating

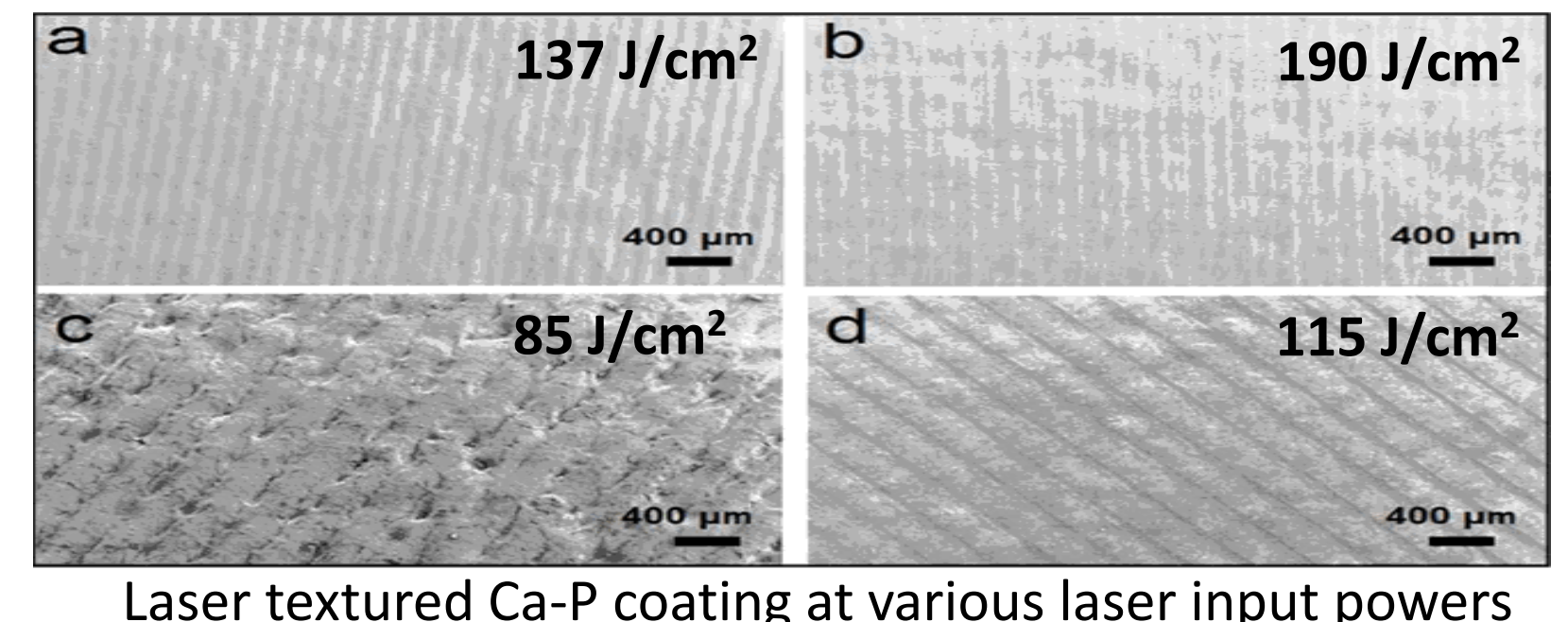


Laser Interference Configuration for Textured Coating



Interference patterning to create periodic surface textures at length scales ranging from the micro to nano in a single step process.

Laser Interference Textured Coating

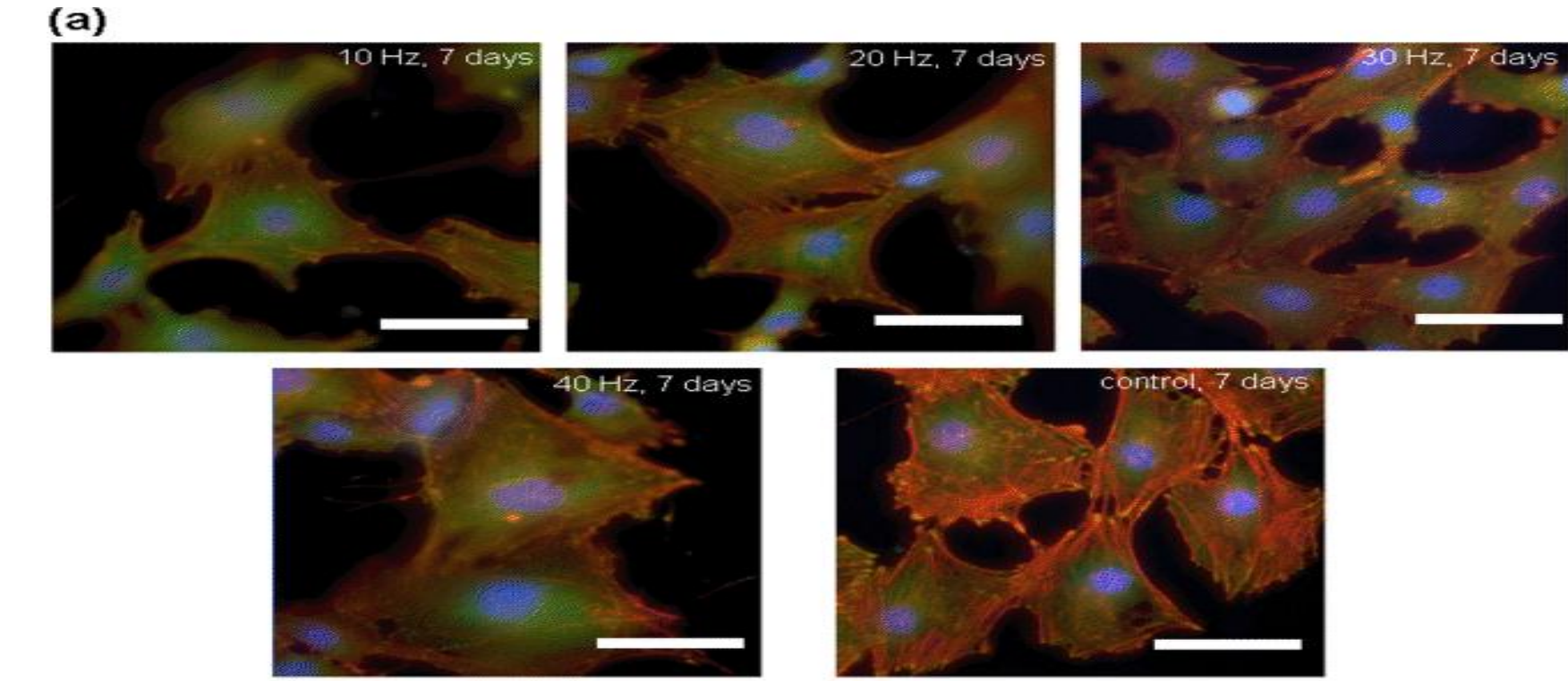


- Multilevel surface texture provides enhanced cell adhesion & proliferation.

Biocompatibility of Textured Coatings

Effect of laser surface modification on biocompatibility of bio-implant materials

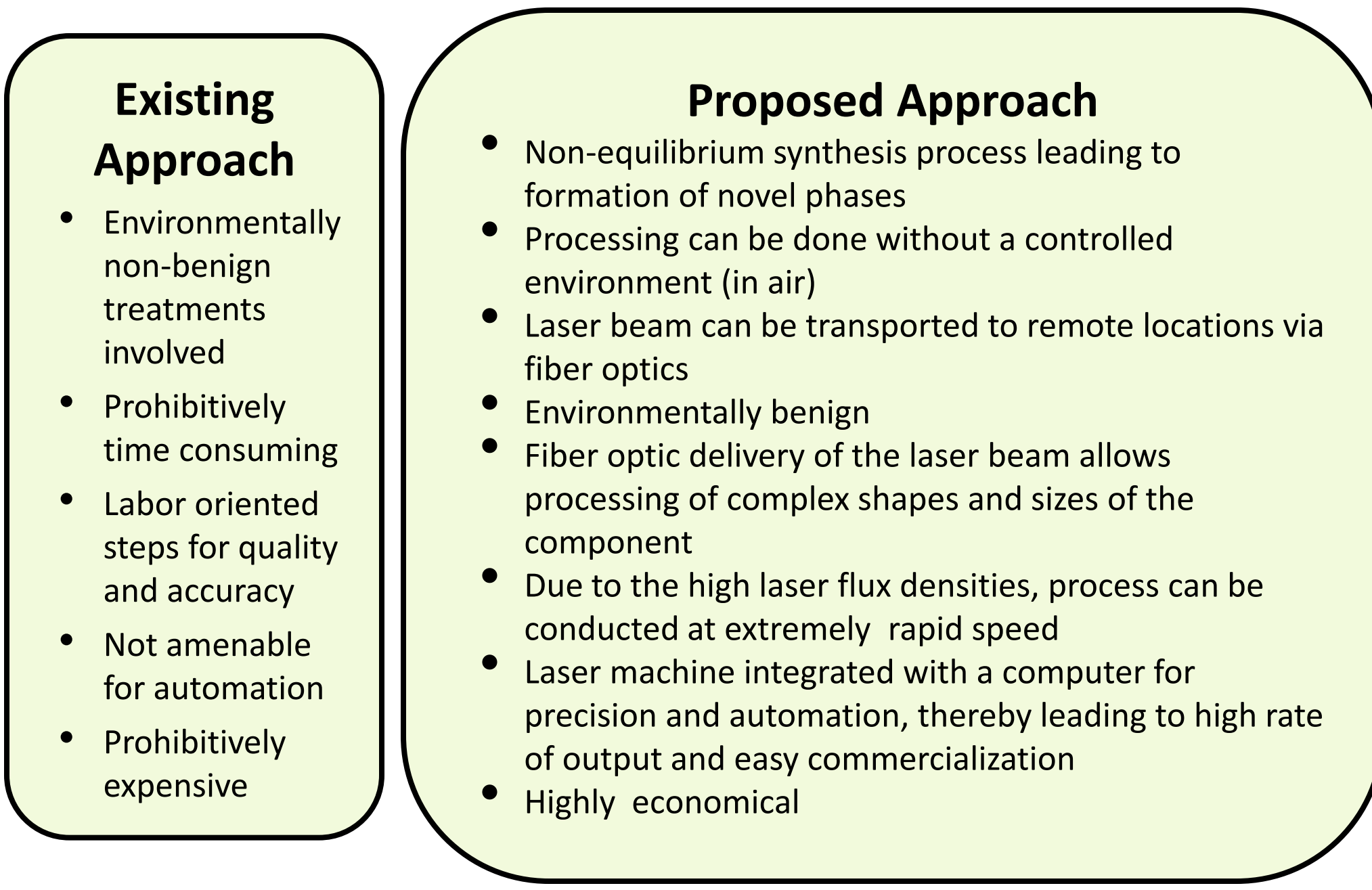
Laser Input Energy (J/cm ²)	Surface Roughness, R _a (microns)	Cell Area x10 ⁴ (mm ²)	Cell Shape Index (4 x pi x area / perimeter ²) (Biocompatibility)	Absorbance 1 Day (Biocompatibility)	Absorbance 3 Days (Biocompatibility)	Absorbance 5 Days (Biocompatibility)
Untreated	10	0.45	0.63	0.039	0.045	0.059
85	29	0.32	0.59	0.040	0.051	0.077
115	35	0.21	0.57	0.035	0.043	0.049
137	71	0.39	0.62	0.037	0.049	0.067
190	74	0.58	0.69	0.035	0.037	0.040



- After applying modifications to the surface of the implant material sample, levels of cell growth on the implant were compared to an untreated sample employing in-vitro culture of mouse MC3T3-E1 osteoblast cells.
- The sample's cell coverage was much more complete than the untreated sample. Also, modifications improved cell adhesion of the laser textured coatings via anchoring of the lamellipodia to the textured grooves and developed network of focal adhesion contacts.

Economic Impact

Present implant manufacturing approaches can be prohibitively laborious and expensive, calling for novel approaches for future implant manufacturing.



By reducing the price and increasing the availability of femoral implants, the hope is to be able to make the surgery accessible to a larger prospective patient base around the globe. In all third-world countries, orthopedic implantation surgery is prohibitively expensive to the masses, and even the surgeries that are carried out, are carried out with reused scraps from previous implant patient whom have passed away. This research could offer a unique solution by providing implants less expensive and last much longer.

Acknowledgement

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- Dr. Sameer Paital formerly of the University of North Texas.
- Dr. Wei He of the University of Tennessee.