Milestone 4 (Team) – Cover Page

Team Number: 26

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Eloise Nguyen	Nguyt126
Rory Sucharov-Gluck	sucharor
Sohail Persaud	persas29
Hassan Bokhari	Bokharh

Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-2 grade.

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

Team Number:	26

You should have already completed **Stage 1** of Milestone 4 individually *prior* to Design Studio 10.

1. Copy-and-paste each team member's **Preliminary Materials Selection** research from the individual worksheets in the tables on the following pages
   → Between the 4-5 team members, all tables should include a minimum of 4 candidate materials
2. Recalling that each team member only needed to consider **TWO** of the three criteria (structure, properties, processing) for **Stage 1**, your team should now fill in any tables not completed for each unique candidate material
   → For example, if a team member proposed *cobalt chrome* and *titanium*, researching the **structure** and **properties** of each, the *team* should then research the **processing** of each of these materials, filling in the appropriate table.

Implant Component:	Femoral Head

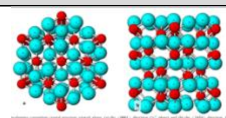
MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION
STRUCTURE

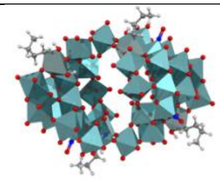
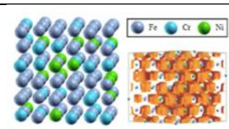
Team Number: 26

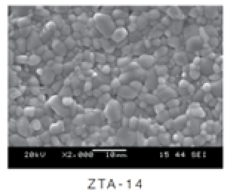
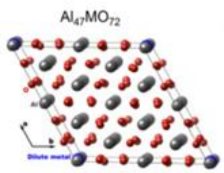
Fill in the Materials Selection table below related to the **STRUCTURE** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

→ Note: some columns include headers (to help get you started) and some are left blank
- Add additional column headers as you feel are appropriate
- You only have to fill in the columns you think are relevant

→ If a candidate material proposed in one of the other tables is not included below, you should add it to this table and fill out the appropriate fields as a *team*

Material	Class	Atomic Arrangement	Interatomic Bonding	Formula		
Ceramic alumina	Ceramic	 - Arranged in crystalline form, repeating structure (Lattice)	- Ionic bonding (metal and non-metal) - Not a hydrogen bond donor (computed)			

Molybdenum	Metallic	 - Body-centered cubic [6] - Lattice constant: a = 3.1470 Å [6]	- Metallic Bonding - Closely Packed atoms			
Ceramic Zirconia	Ceramic	- hexagonal structure - Monoclinic crystalline structure	Ionic bonding between Zr and O			
Carbon Fiber	Polymer	Carbon nanotubes made of hexagons (only carbons present)	Non-polar covalent bonds with the other Carbon atoms			
316L AISI Alloyed Stainless Steel	Metal alloy/ Ferritic	 Figure 1: The 108 atoms supercell of 316L stainless steel generated with the SQS method (left). [2]	- Metallic Bonding - Method towards creating alloy and metallic bonds involves Thermoplastic Bonding (TPB) creating atomic	Fe73Cr21Ni14 [2]		

		Ferritic – cube, shape, crystal, structure [2]	diffusion at high temperatures [3]			
BIOLOX Delta (patented name) Professionally known as Zirconia-toughened alumina – 14 (ZTA – 14)	Composite Ceramics	 [6]  [7] Monoclinic crystalline structure transformed from compressed tetragonal crystal structure [6]	- Zr-O bonds quantify many strength properties of material. [7] - Strong interatomic bonding in comparison with other RE's (reactive elements) [7] -Ionic bonding [6]	Zr-Al_2O_3 [6]		

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

PROPERTIES

Team Number: 26

Fill in the Materials Selection table below related to the **PROPERTIES** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

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Material	Elastic Modulus	Ultimate Strength	Toughness, Fracture	Wear	Corrosion Resistance	
Silicon Carbide	410 GPa	390 MPa	4.60 MPa*m$^{1/2}$	Si_3N_4 sliding against Si_3N_4 showed low wear rate in both bovine serum and PBS. High wear resistance [3]	It resists against common acids: (hydrochloric acid, sulfuric acid, hydrobromic acid, and hydrofluoric acid). Resistant	

					against bases (amines, potash and caustic soda) and solvents and oxidizing media.	
Ceramic alumina	380GPa	325MPa	2.3 ± 0.2 MPa $m^{1/2}$	High wear resistance In Alumina ceramics, the wear rate is as low as 0.00052%	High corrosion resistance Resistance of alumina in aqueous solutions containing 0.1 mol/kg H_2SO_4, H_3PO_4 or HCl at T = 240°C–500°C is at p = 27 MPa	Excellent
Molybdenum alloy	343GPa	2100 MPa	40 MPa.m1/2	Very good	High corrosion resistance	Good
316L AISI Alloyed Stainless Steel	200 GPa [8]	586 MPa [8]	112-278 MPa m1/2 [9]	High wear resistance that can be increased with	Superior corrosion resistant	- Studies show biocompatibility of metal inside human body

				surface coating [10]	compared to other metals [8] -Performs well against corrosion in fresh water and saltwater systems [8] -Studies do show slight susceptibility to corrosion in biological environment long term. [10]	applications of implants etc. [10] - Adequate osteointegration [10] - Demonstrates superior biocompatibility [10]
BIOLOX Delta (patented name) Professionally known as Zirconia-toughened alumina – 14 (ZTA – 14) [4]	338 GPa [6]	689 MPa [11]	5-7 MPa. m1/2 [11]	Very hard and wear resistant [11]	-Very high corrosion strength even when put under pressure in different temperature environments [11]	-Relatively low volume to weight ratio advantageous to medical applications [11] -Suitable for orthopedic load-bearing components [12] -No adverse tissue reactions after implantation [12] -Great biocompatibility [12] -Chemical inertness [12]

						-Doesn't account for osteointegration [12]

MILESTONE 4 (STAGE 2) – MATERIALS SELECTION GROUP DISCUSSION

PROCESSING

Team Number: 26

Fill in the Materials Selection table below related to the **PROCESSING** of the material by *copy-and-pasting* each team members individual research. Discuss your findings as a team.

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Material	Coatings	Drug Delivery Options	Corrosion Resistance			
Ceramic Alumina	– Polyaleuritate coatings, self-esterized from naturally occurring	-surgical implantation of the femoral head made of this material	- Hard to corrode by HCl, easier by hydrofluoric and hydrochloric acid			

	fatty polyhydrodroxyacids. – Organic coating (formed by carbon-based polymeric chains derived from natural or synthetic matter) – Alclad (corrosion-resistant aluminum sheet to strengthen alumina)	attached to a femoral stem, both being coated with a protective barrier and assembled with the socket in the body.				
Silicon carbide	- Can be used as coating for hip replacement - Plasma spray coatings for biocompatibility and protection against corrosion and wear	- surgical implantation of the femoral head made of this material attached to a femoral stem, both being coated with a protective barrier and assembled with the socket in the body.	- Plasma spray - The material itself is resistant to corrosion			

Ceramic Zirconia	Possible zirconia coatings on stainless steel through laser/sol-gel technique	Mesoporous zirconia nanoparticles (MZNs) due to high surface area and biocompatibility	Relatively high corrosion resistance along with relatively high wear resistance			
Carbon Fiber	Vaporizing hydrocarbons can create pyrolytic carbon, a carbon fiber coating	Carbon Nanotubes (CNTs) have an ideal structure for drug delivery options	High resistance to corrosion, which makes it great for bio-integration			

MILESTONE 4 (STAGE 3) – PROPOSED MATERIAL

Team Number:	26

Based on the previous tables, identify the material you consider as being most appropriate for this component

Proposed Material:	Carbon coating around

	Cobalt – Chromium - Molybdenum

Explain why you selected this material based on the structure, properties and processing:

The material has high biocompatibility, good wear (with carbon coating), high corrosion resistance, high ultimate strength, high corrosion resistance and reduces friction.

Comment on why the material selected makes the most sense ***for your patient***

Due to the patient's lifestyle, the implant must be designed to be long lasting and accommodate the patient's weight. Cobalt – Chromium – Molybdenum has good wear, meaning that it could last a long time without need for replacement. The material has a high ultimate strength, which would endure the patient's weight.