Project Notes:

Project Title: **Puppy Prosthetics: A Method for Mobility Rehabilitation Implementing 3D Design**
Name: **Smita Bhogle**

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times so set aside enough time in your schedule.

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https://www.sciencemag.org/news/2021/08/climate-change-drying-out-many-part-time-streams-united-states 5

Mini Summary: Human activities, mainly climate change, have been contributing to extreme temperatures. Many small seasonal streams have been drying out recently. This negatively impacts organisms and water quality. 5

Central Question: What are the effects of climate change? 5

Ephemeral: lasting for a short time 6

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"Pistachios wallop walnuts as the toughest nut to crack" 7

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Can artificially altered clouds save the Great Barrier Reef? 8

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Three dimensional printed macroporous polylactic acid/hydroxyapatite composite scaffolds for promoting bone formation in a critical-size rat calvarial defect model **44**

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Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
How do prosthetics work?	Reading Journal Articles	Journal Articles 6-8	10/05/2021
What prosthetics are available for animals?	Reading Journal Articles	Journal Articles 9-10	10/20/2021
What is the prosthetic process for a dog?	Reading Journal Articles	Journal Article 13	11/03/2021

Literature Search Parameters:

These searches were performed between 09/16/2021 and 12/06/2021.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
WPI Gordon Library	Prosthetics, Arms, Legs, Mechanics, Animals, Orthotics	Learned more about the intricacies of prosthetics, found JA #6-#9
WPI Gordon Library	Dog, prosthetic	Learned about the current solutions for dog amputees
WPI Gordon Library	3D printing, prosthetic	Learned about the current scope and engineering design process for 3D printed prosthetics

Article #1 Notes: "Climate change is drying out many part-time streams in the United States"

Source Title	"Climate change is drying out many part-time streams in the United States"
Source citation (APA Format)	Erik Stokstad Aug. 12, 2. (2021, August 12). Climate change is drying out many part-time streams in the United States. Retrieved from https://www.sciencemag.org/news/2021/08/climate-change-drying-out-many-part-time-streams-united-states
Original URL	https://www.sciencemag.org/news/2021/08/climate-change-drying-out-many-part-time-streams-united-states
Source type	General Science Journal
Keywords	Climate change, temperature, dry
Summary of key points (include methodology)	Mini Summary: Human activities, mainly climate change, have been contributing to extreme temperatures. Many small seasonal streams have been drying out recently. This negatively impacts organisms and water quality.
Research Question/Problem/ Need	Central Question: What are the effects of climate change?

Important Figures	
Notes	Ephemeral: lasting for a short time Flow gauges: devices that measure the rate that liquids flow through a system ecohydrologist : combined science of ecology and hydrology
Cited references to follow up on	N/A
Follow up Questions	Questions: 1. How can the drying of these streams be slowed down? 2. How can water quality be improved? 3. How can the surrounding organisms be helped?

Article #2 Notes: “Pistachios wallop walnuts as the toughest nut to crack”

Source Title	“Pistachios wallop walnuts as the toughest nut to crack”
Source citation (APA Format)	Christa Lesté-Lasserre Aug. 10, 2. (2021, August 10). Pistachios wallop walnuts as the toughest nut to crack. Retrieved from https://www.sciencemag.org/news/2021/08/pistachios-wallop-walnuts-toughest-nut-crack
Original URL	https://www.sciencemag.org/news/2021/08/pistachios-wallop-walnuts-toughest-nut-crack
Source type	General Science Journal
Keywords	Crack, shell, structure, cells
Summary of key points (include methodology)	Mini Summary: Many nuts are difficult to open because of the cellular organization of their shells. Usually materials are either stiff and brittle or tough and flexible, but pistachio and walnut shells are both. This is what makes them so hard to open.
Research Question/Problem/ Need	Central Question: Why are nuts so hard to crack open?
Important Figures	

Notes	Tomography scanner: CT scan Biomechanics: application of mechanical principles to life Tensile strength: resistance of a material
Cited references to follow up on	N/A
Follow up Questions	Questions: 1. Are there ways for people with limited hand mobility to open crack nut shells? 2. What are things that would benefit from having shells/ a protector similar to nuts 3. How can nut shell cracking be automated?

Article #3 Notes: **Can artificially altered clouds save the Great Barrier Reef?**

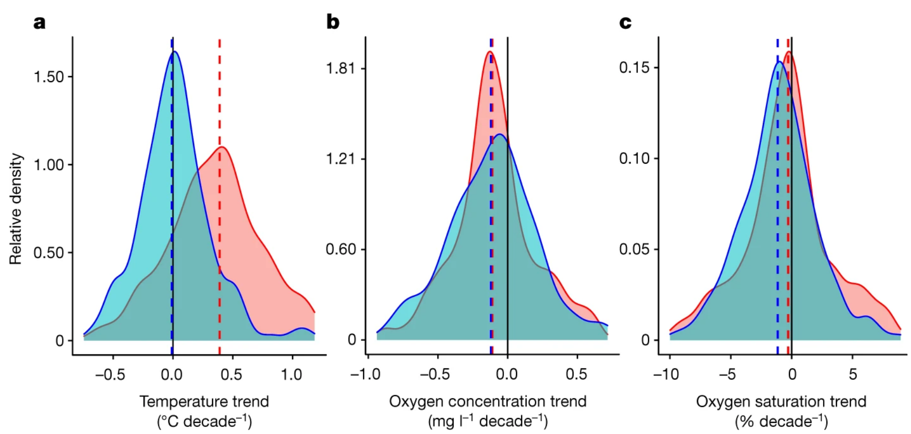
Source Title	**Can artificially altered clouds save the Great Barrier Reef?**
Source citation (APA Format)	Tollefson, J. (2021, August 25). Can artificially altered clouds save the Great Barrier Reef? Retrieved from https://www.nature.com/articles/d41586-021-02290-3
Original URL	https://www.nature.com/articles/d41586-021-02290-3
Source type	Science journal news
Keywords	Ocean, environment, coral reef, money
Summary of key points (include methodology)	Australian researchers used turbines to get ocean water to mist over the Great Barrier Reef. These artificial clouds were used to help block harsh sun rays from damaging the coral reef. This is being used to try and soften the negative impacts of climate change.
Research Question/Problem/ Need	What are ways to help marine life?

Important Figures	
Notes	Geoengineering: the intentional large-scale intervention in the Earth's/ climate to reduce the impact of climate change. Net zero emissions: balancing the amount of greenhouse gasses taken and removed from the environment Greenhouse gasses: human produced gasses that contribute to climate change Coral aquaculture: to cultivate coral for coral reef restoration
Cited references to follow up on	N/A
Follow up Questions	1. How helpful is this? 2. Is it worth the fake clouds? 3. Are there more natural/ efficient ways to emulate this? 4. How can this technology be made more accessible? 5. What are long term effects?

Article #4 Notes: "**Widespread deoxygenation of temperate lakes"**

Article notes should be on separate sheets

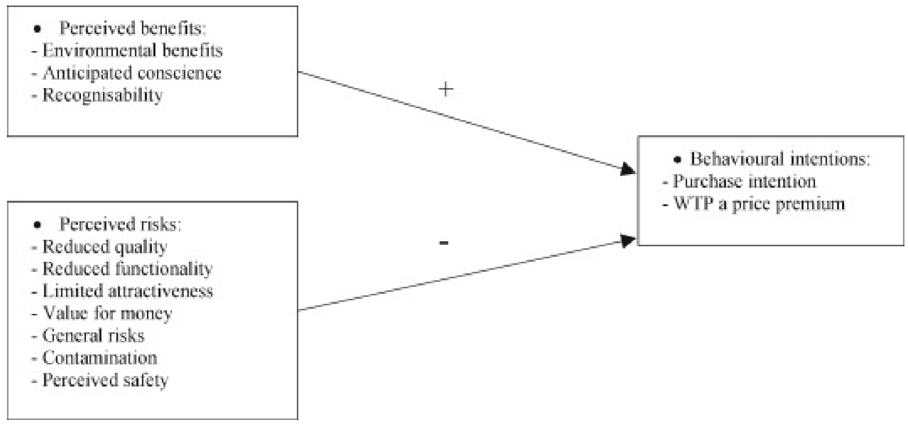
Source Title	"Widespread deoxygenation of temperate lakes"

Source citation (APA Format)	Jane, Stephen F., et al. “Widespread Deoxygenation of Temperate Lakes.” *Nature*, vol. 594, no. 7861, 2021, pp. 66–70., https://doi.org/10.1038/s41586-021-03550-y.
Original URL	https://www.nature.com/articles/s41586-021-03550-y#article-info
Source type	Science Journal
Keywords	Biodiversity, greenhouse gasses, oxygen, algae
Summary of key points (include methodology)	Overtime, the oxygen levels in lakes have been depleting. This deoxygenation has been linked to human caused climate change, and it impacts water quality which is detrimental to many organisms. It also encourages algae blooms which is harmful to other organisms.
Research Question/Problem/ Need	How does climate change impact the environment? What are ways to fix problems caused by climate change?
Important Figures	
Notes	Biogeochemistry: the study of what chemical elements are like in their physical environments Thermal stratification: when water in lakes form layers caused by the sun’s heat Phytoplankton: microscopic marine algae heterotrophic respiration: carbon lost by organisms in their ecosystems Eutrophication: excessive nutrients in a body of water
Cited references to follow up on	Dr Kevin Rose, RPI (rosek4@rpi.edu)

Follow up Questions	1. How can algal blooms be reduced? 2. What preventative measures can be taken? 3. Can common people test water quality easily on their own?

Article #5 Notes: "**Turning ocean garbage into products – Consumers' evaluations of products made of recycled ocean plastic**"

Source Title	"Turning ocean garbage into products – Consumers' evaluations of products made of recycled ocean plastic"
Source citation (APA Format)	Magnier, L., Mugge, R., & Schoormans, J. (2019). Turning ocean garbage into products – Consumers' evaluations of products made of recycled ocean plastic. *Journal of Cleaner Production, 215*, 84-98. doi:10.1016/j.jclepro.2018.12.246
Original URL	https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S0959652618339684
Source type	Science Journal
Keywords	Ocean, Plastic, Pollution, Sustainability
Summary of key points (include methodology)	Some plastic from the ocean is recycled and used as packaging for products. This is a good idea, but there are multiple complications when using recycled materials. Oftentimes, it isn't as appealing to consumers due to the fact that they believe that they are lower quality. Many factors such as graphic design, product expectations, and perceived risks impact people's opinions.
Research	How can ocean pollution be improved?

Question/Problem/ Need	
Important Figures	
Notes	Cluster analysis: Cluster analysis is grouping a set of objects in such a way that objects in the same group are more similar than to those in other groups. Ocean detritus: organic materials that floats or sinks in the ocean Segmentation: a marketing technique used to divide broad groups Pairwise comparisons: comparing sets of pairs against each other Promax rotation: data analysis technique
Cited references to follow up on	Lise Magnier, Ruth Mugge, Jan Schoormans (Netherlands)
Follow up Questions	1. How can recycled packaging be ensured that it's clean? 2. How can packaging be optimized to have a smaller carbon footprint? 3. How can recycled packaging be made more standardized/ trusted?

Article #6 Notes:

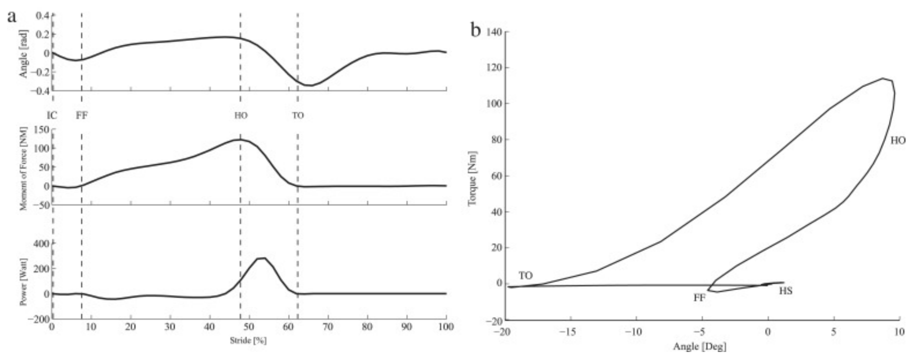
Source Title	“Advanced Upper Limb Prosthetic Devices: Implications for Upper Limb Prosthetic Rehabilitation”
Source citation (APA Format)	Resnik, L., Meucci, M. R., Lieberman-Klinger, S., Fantini, C., Kelty, D. L., Disla, R., & Sasson, N. (2012). Advanced Upper Limb Prosthetic Devices: Implications for Upper Limb Prosthetic Rehabilitation. *Archives of Physical Medicine and Rehabilitation, 93*(4), 710-717. doi:10.1016/j.apmr.2011.11.010
Original URL	https://www.sciencedirect.com/science/article/pii/S0003999311009750
Source type	Science Journal
Keywords	Prosthetics, Technology, Implications,
Summary of key points (include methodology)	Prosthetics are assistive technology devices for amputees. They are very helpful, but they can be very expensive, and they don’t imitate human limbs very well.
Research Question/Problem/ Need	How can prosthetics be improved?

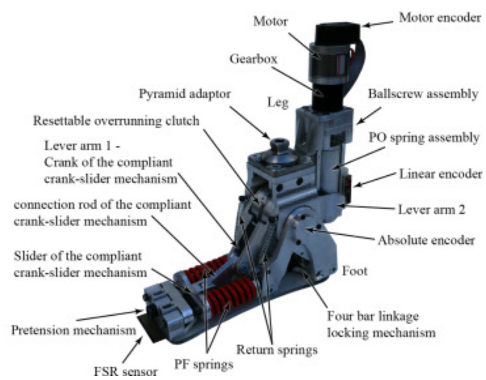
<table>
<tr><td>Important Figures</td><td>Table 1. Comparison of Costs for Body-Powered and Externally Powered Prostheses*
<table>
<tr><th>Type of Device</th><th colspan="2">Type of Control</th></tr>
<tr><td>Upper limb prostheses</td><td>Body powered</td><td>Externally powered</td></tr>
<tr><td>Transhumeral</td><td>$5,000–$10,000</td><td>$50,000–$75,000</td></tr>
<tr><td>Transradial</td><td>$4,000–$8,000</td><td>$25,000–$50,000</td></tr>
<tr><td>Lower limb prostheses</td><td>Nonpowered (no microprocessors)</td><td>Microprocessor controlled</td></tr>
<tr><td>Transfemoral</td><td>$15,000–$25,000</td><td>$50,000–$100,000+</td></tr>
<tr><td>Transtibial</td><td>$5,000–$15,000</td><td>$40,000–$100,000</td></tr>
</table>
*</td></tr>
<tr><td>Notes</td><td>Traumatic amputation: loss of a body part due to an accident
Transhumeral: When the humerus is removed from the body
Myoelectric: electric properties of muscles
Phantom Pain: consequence of losing a body part
Cumulative trauma disorders: When someone’s body cannot heal fast enough</td></tr>
<tr><td>Cited references to follow up on</td><td>N/A- references are too outdated</td></tr>
<tr><td>Follow up Questions</td><td>1. How can prosthetics be cheaper?
2. How can prosthetics be more versatile?
3. How can prosthetics be more sensitive (like human touch)?</td></tr>
</table>

Article #7 Notes:

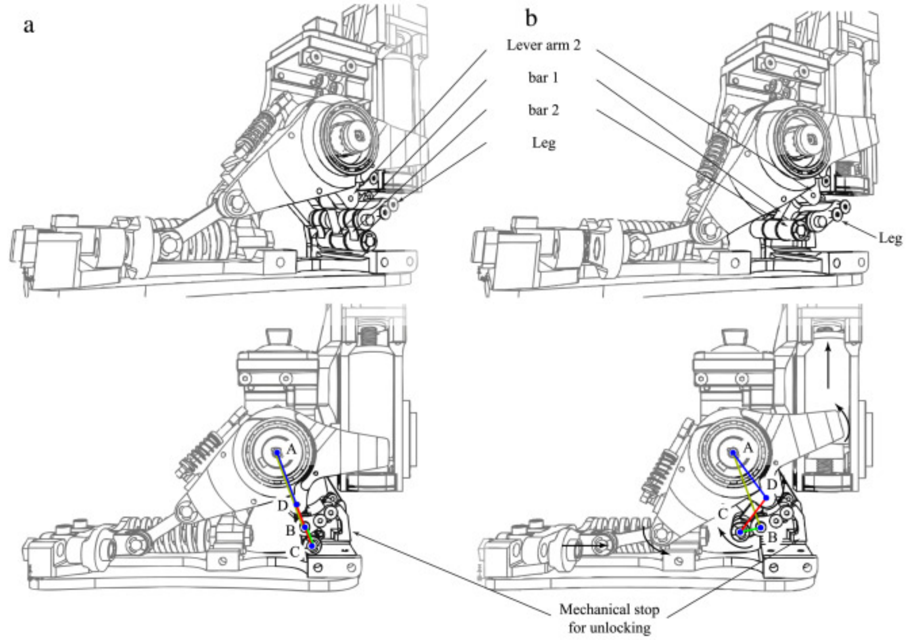
Source Title	“The Ankle Mimicking Prosthetic Foot 3—Locking mechanisms, actuator design, control and experiments with an amputee”
Source citation (APA Format)	Cherelle, P., Grosu, V., Flynn, L., Junius, K., Moltedo, M., Vanderborght, B., & Lefeber, D. (2017). The Ankle Mimicking Prosthetic Foot 3—Locking mechanisms, actuator design, control and experiments with an amputee. *Robotics and Autonomous Systems, 91*, 327-336. doi:10.1016/j.robot.2017.02.004
Original URL	https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S0921889016302974
Source type	Science Journal
Keywords	Prosthetics, foot, mechanics
Summary of key	Prosthetic feet seem simple, but they are actually very intricate due

<table>
<tr><td>points (include methodology)</td><td>to human ankles. Human ankles are an essential part of walking, but everyone uses theirs uniquely. The AMP- uses a special type of actuation (Explosive Elastic Actuator) and (Series Elastic Actuator) to maximize the function of prosthetic ankles. It uses systems like and similar to servos, drop wheels, and ball and socket joints. They tested their prototypes on multiple amputee subjects, all with different walking cadences. The data demonstrates this.</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>How do prosthetic feet work?</td></tr>
<tr><td>Important Figures</td><td>

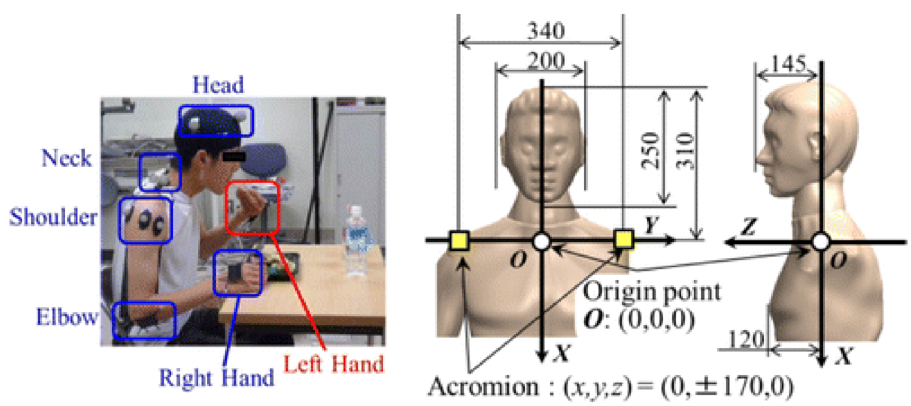


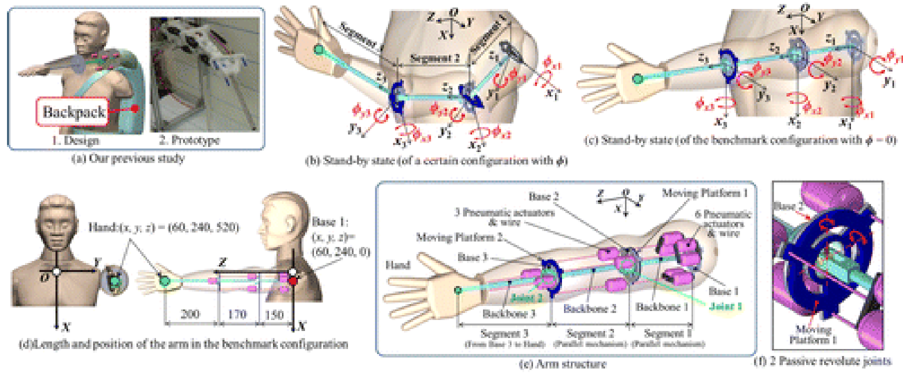
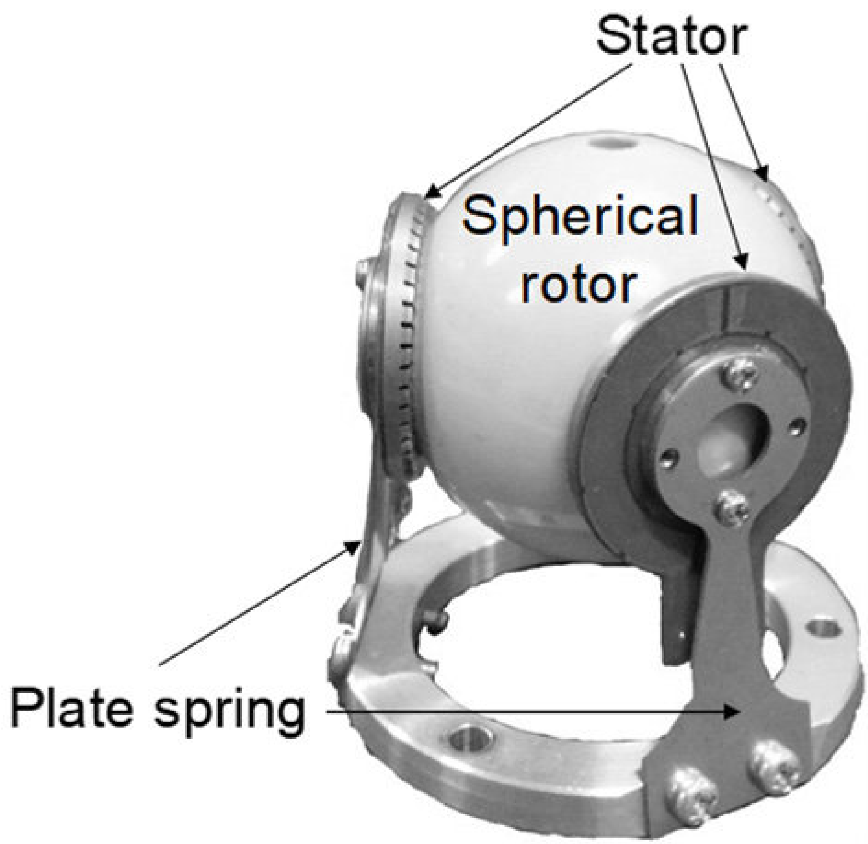


</td></tr>
</table>

	
Notes	Bionics: the application of biological methods in nature to engineering and modern technology Plantarflexion: when the top of your foot points away from your leg Dorsiflexion: when the top of your foot points to your leg Transfemoral amputation:amputation above the knee Actuation: source/input of a machine
Cited references to follow up on	Vrije Universiteit Brussel, Belgium P. Cherelle, V. Grosu, A. Matthys, B. Vanderborght and D. Lefeber, "Design and Validation of the Ankle Mimicking Prosthetic (AMP-) Foot 2.0," in *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 22, no. 1, pp. 138-148, Jan. 2014, doi: 10.1109/TNSRE.2013.2282416. Q. Wang, K. Yuan, J. Zhu and L. Wang, "Walk the Walk: A Lightweight Active Transtibial Prosthesis," in *IEEE Robotics & Automation Magazine*, vol. 22, no. 4, pp. 80-89, Dec. 2015, doi: 10.1109/MRA.2015.2408791.
Follow up Questions	1. How can this technology be made more inexpensive? 2. How can this be more generic? 3. Can this technology be applied to other prosthetic limbs? 4. What is maintenance like?

Article #8 Notes:

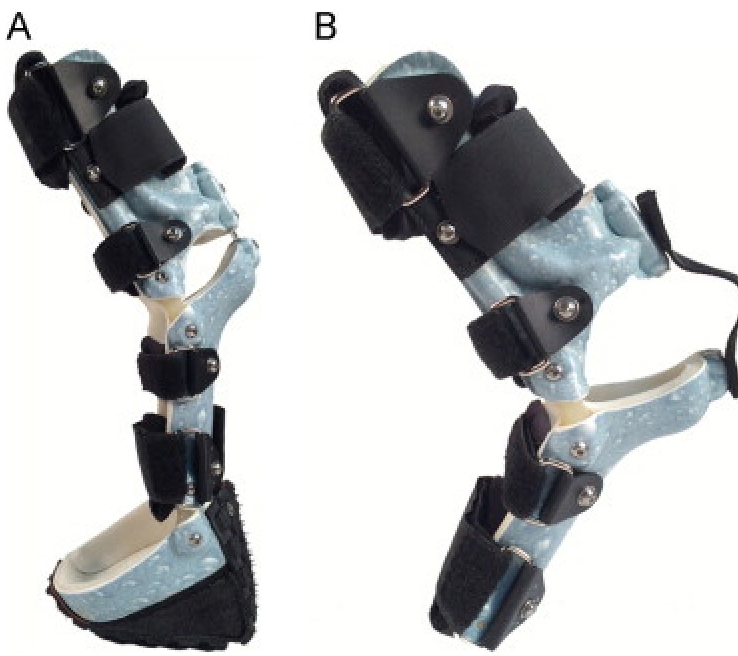
Source Title	“Optimization-Based Design of a Small “Pneumatic-Actuator-Driven Parallel Mechanism for a Shoulder Prosthetic Arm with Statics and Spatial Accessibility Evaluation”
Source citation (APA Format)	Sekine, M., Sugimori, K., Gonzalez, J., & Yu, W. (2013). Optimization-Based Design of a Small Pneumatic-Actuator-Driven Parallel Mechanism for a Shoulder Prosthetic Arm with Statics and Spatial Accessibility Evaluation. *International Journal of Advanced Robotic Systems, 10*(7), 286. doi:10.5772/56638
Original URL	https://journals.sagepub.com/doi/full/10.5772/56638
Source type	Science Journal
Keywords	Prosthetics, Mechanics, Arm, Pneumatics
Summary of key points (include methodology)	Human arms are very important limbs. Most of the tasks we complete are with our hands and arms. Prosthetic arms need to account for this and fit weight, flexibility, and functionally constraints. Usually, motors are primarily used in prosthetics, but this study analyzed if trading space to use pneumatic actuators was worth it. They determined that it could be based on the individual.
Research Question/Problem/ Need	How do prosthetic arms work?
Important Figures	 (a) Markers of motion tracking (b) 3D human data and coordinate system

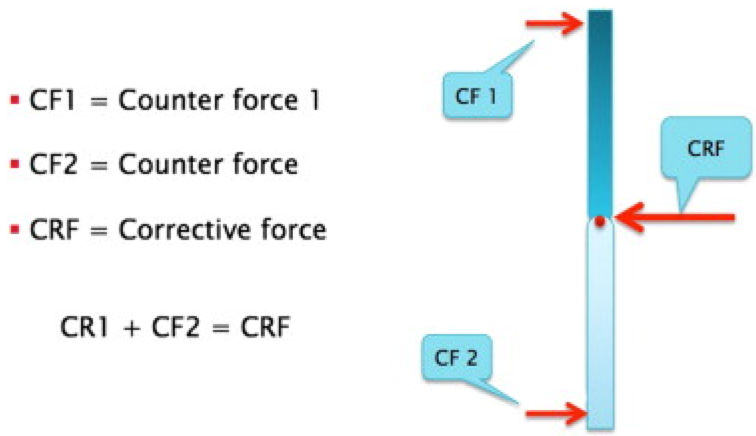
	
Notes	Pneumatic: operated by air Spatial Accessibility: how easy it is to access healthcare Viscoelasticity: materials that have elastic and viscous properties when deforming ADL: activities of daily life spherical ultrasonic motor:  https://www.researchgate.net/figure/Photograph-of-spherical-ultrasonic-motor_fig1_330025372
Cited references to	Research Center for Frontier Medical Engineering, Chiba University, Japan

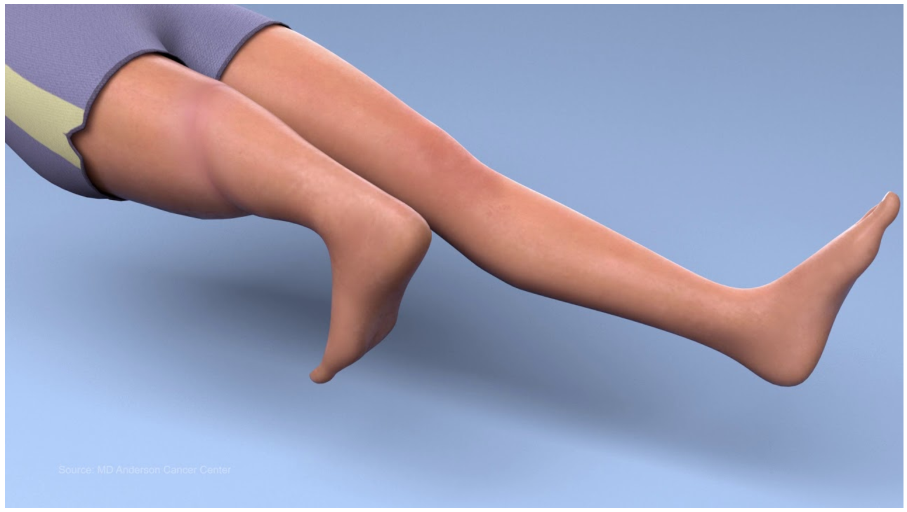
follow up on	*cited sources are in japanese*
Follow up Questions	1. How can this be made more generic? (reoccurring) 2. What aspects of this model can be replicated easily? 3. How sustainable are prosthetics? 4. How are prosthetics disposed of?

Article #9 Notes:

Source Title	"The Emerging Role of Veterinary Orthotics and Prosthetics (V-OP) in Small Animal Rehabilitation and Pain Management"
Source citation (APA Format)	Mich, P. M. (2014). The Emerging Role of Veterinary Orthotics and Prosthetics (V-OP) in Small Animal Rehabilitation and Pain Management. *Topics in Companion Animal Medicine, 29*(1), 10-19. doi:10.1053/j.tcam.2014.04.002
Original URL	https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S1938973614000075
Source type	Science Journal
Keywords	Prosthetics, Animals, Ecology, Environment, Orthotics
Summary of key points (include methodology)	Humans have started to apply human orthotic and prosthetic knowledge and principles to animals. This is not the first medical technology to be transferred to animals, other examples include dentistry, acupuncture, and chiropractic techniques. Most of the current animal "prosthetics" are more similar to casts and braces than human prosthetics.
Research Question/Problem/ Need	Do animals have access to prosthetics?
Important Figures	

	  A B

	 
Notes	Orthoses: A medical device attached to the body that helps it in someway Microprocessors: mini electronic device (i.e SD card) intraosseous transcutaneous amputation prosthesis: attaching a prosthetic directly to skeleton Rotational Plasty:

	 https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DzuMH3u0OLhA&psig=AOvVaw3IK2PZ7ucHYOIoLCQ2LuFV&ust=1632809450269000&source=images&cd=vfe&ved=0CAwQjhxqFwoTCOD5jqy_nvMCFQAAAAAdAAAAABAD Ligament rupture: injuries to the soft tissues that connect muscles and joints
Cited references to follow up on	Contact local shelters, animal hospitals, talk to Robin https://cahvets.com/?utm_source=google&utm_medium=organic&utm_campaign=gmb&utm_term=website https://vetmed.tufts.edu/tufts-at-tech/
Follow up Questions	1. Have prosthetics been developed for all animals? 2. How do animal amputations work? 3. Would this only be good for domesticated animals? 4. Can similar myoelectric sensors be used on animals?

Article #10 Notes:

Source Title	“Kinetics of individual limbs during level and slope walking with a unilateral transtibial bone-anchored prosthesis in the cat”
Source citation (APA Format)	Jarrell, J. R., Farrell, B. J., Kistenberg, R. S., Dalton, J. F., Pitkin, M., & Prilutsky, B. I. (2018). Kinetics of individual limbs during level and slope walking with a unilateral transtibial bone-anchored prosthesis in the cat. *Journal of Biomechanics, 76*, 74-83. doi:10.1016/j.jbiomech.2018.05.021
Original URL	https://www.sciencedirect.com/science/article/pii/S0021929018303877
Source type	Science Journal Article
Keywords	Animal, prosthetics, limbs, veterinary
Summary of key points (include methodology)	It’s not common to apply human prosthetic techniques to veterinary medicine, but Bone-anchored transcutaneous prostheses can be used to help animals as well. Right now, if a cat or dog loses a leg, they usually have to continue life with three legs. This leads to many problems including limited mobility, weight gain, and premature euthanasia. This study tested to see if cats would be able to utilise a prosthetic while walking downslope, level, and on upslope terrain.
Research Question/Problem/ Need	What kind of prosthetics exist for animals?

Important Figures	

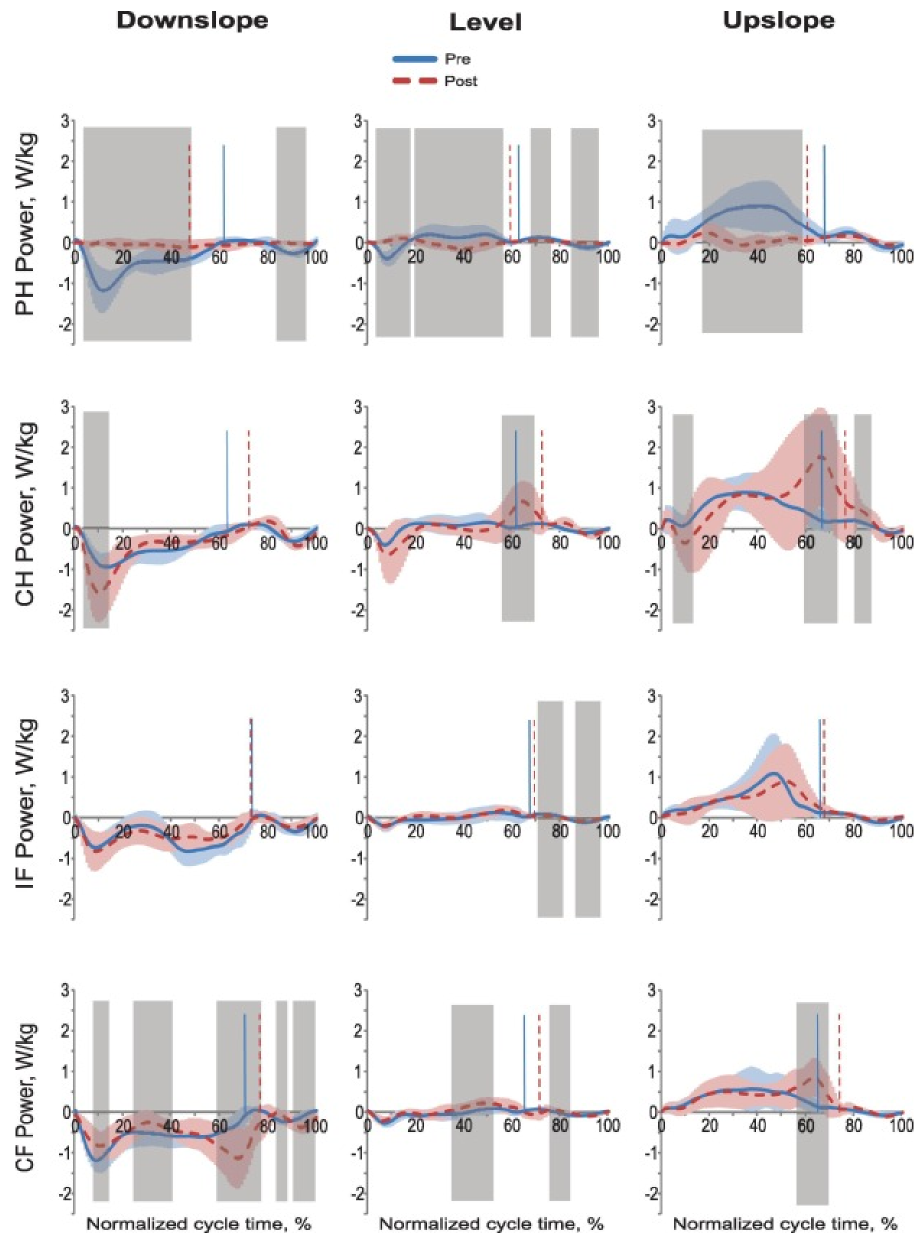


Table 1. Animal characteristics.

Cat characteristics	QM04	09NHT4	11NLS4	QMV5	Mean ± SD
Baseline mass, kg	3.2	3.2	3.2	3.0	3.15 ± 0.10
Terminal mass, kg	4.0	3.4	2.8	4.0	3.55 ± 0.57
Estimated mass of the foot and distal third tibia, g	54.1	52.5	49.5	51.2	51.8 ± 2.0
Estimated moment of inertia of the foot and distal third tibia, g cm^2	290	326	279	281	294 ± 22
Prosthesis mass, g	15.5	15.5	18.4	18.4	17.0 ± 1.8
Prosthesis moment of inertia with respect to frontal axis through prosthesis center of mass, g cm^2	172	172	157	157	164.5 ± 8.7
Baseline walking speed, m/s					
Level	0.67 ± 0.06	0.46 ± 0.02	–	0.54 ± 0.04	0.56 ± 0.10
Downslope	0.75 ± 0.14	0.55 ± 0.06	0.58 ± 0.10	–	0.61 ± 0.13
Upslope	0.56 ± 0.21	0.40 ± 0.07	0.71 ± 0.20	–	0.55 ± 0.20

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distal third tibia, g cm²					
Prosthesis mass, g	15.5	15.5	18.4	18.4	17.0±1.8
Prosthesis moment of inertia with respect to frontal axis through prosthesis center of mass, g cm²	172	172	157	157	164.5±8.7
Baseline walking speed, m/s					
Level	0.67±0.06	0.46±0.02	–	0.54±0.04	0.56±0.10
Downslope	0.75±0.14	0.55±0.06	0.58±0.10	–	0.61±0.13
Upslope	0.56±0.21	0.40±0.07	0.71±0.20	–	0.55±0.20
Terminal walking speed, m/s					
Level	0.50±0.07	0.39±0.03	–	0.40±0.03	0.44±0.07*
Downslope	0.61±0.07	0.32±0.08	0.59±0.07	–	0.47±0.16*
Upslope	0.54±0.14	0.41±0.09	0.42±0.04	–	0.47±0.12*

Notes: The term 'Terminal' designates measurements taken several days before euthanasia. Asterisks '*' indicate significant difference ($p<0.05$) between intact and prosthetic walking.

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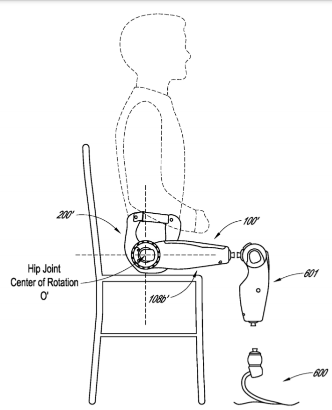
Help

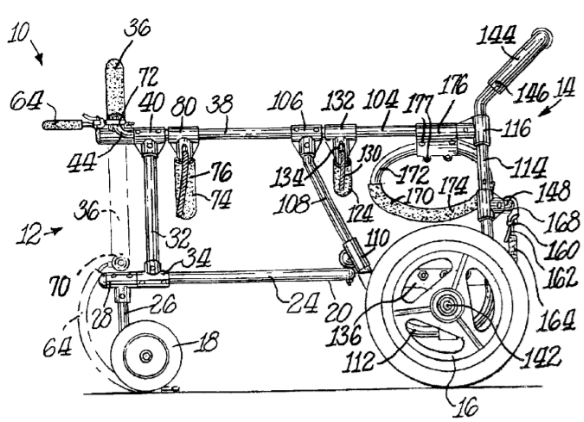
Notes	Unilateral: happening on only one side of a body organ or structure Transtibial: amputation involving the tibia Transcutaneous: measured across the depth of the skin Locomotion: act of moving place to place Quadrupedal: a four footed animal
Cited references to follow up on	McFadyen, B., Lavoie, S. & Drew, T. Kinetic and energetic patterns for hindlimb obstacle avoidance during cat locomotion. *Exp Brain Res* 125, 502–510 (1999). https://doi.org/10.1007/s002210050708 DRYGAS, K.A., TAYLOR, R., SIDEBOTHAM, C.G., HUGATE, R.R. and MCALEXANDER, H. (2008), Transcutaneous Tibial Implants: A Surgical Procedure for Restoring Ambulation After Amputation of the Distal Aspect of the Tibia in a Dog. Veterinary Surgery, 37: 322-327. https://doi.org/10.1111/j.1532-950X.2008.00384.x
Follow up Questions	1. How common are animal amputations? 2. How similar are the body mechanics of a cat and dog? 3. Do animal prosthetics need to be as customized as well? 4. How can animal prosthetics be tested?

Article #11 (Patent) Notes:

Source Title	"Powered prosthetic hip joint"
Source citation (APA Format)	Langlois, David (Saint-Jacques-de-Leeds, CA), Clausen, Arinbjörn Viggo (Reykjavik, IS), Einarsson, Árni (Reykjavik, IS), 2015 Powered prosthetic hip joint United States Össur hf

	(Reykjavik, IS), 9044346 https://www.freepatentsonline.com/9044346.html
Original URL	https://www.freepatentsonline.com/9044346.pdf
Source type	Patent
Keywords	Prosthetic, human, hip, leg
Summary of key points (include methodology)	This patent is for a hip prosthetic mechanism. The hip joint is motorized which allows for it to be mechanically connected to a leg prosthetic. The prosthetic can make up for an entirely lost leg. The hip can also be connected with a prosthetic knee.
Research Question/Problem/ Need	What patents for prosthetics are on the market?
Important Figures	
Notes	Lateral-medial: Proximal: near the center Distal: away from the center Flexion: bending an arm or leg Sagittal plane: divides the body into right and left
Cited references to follow up on	N/A
Follow up Questions	1. Are most prosthetics so big? 2. How are repairs made to prosthetics? 3. What materials are needed? 4. What is the “lifespan” of this?

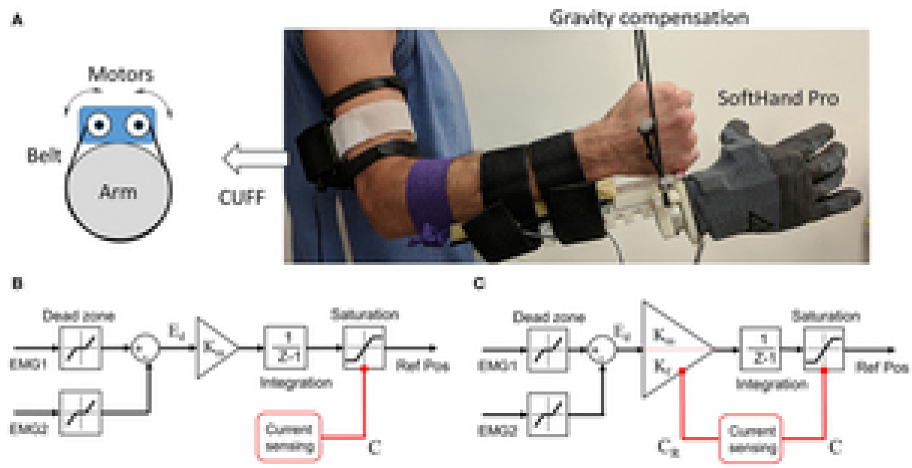
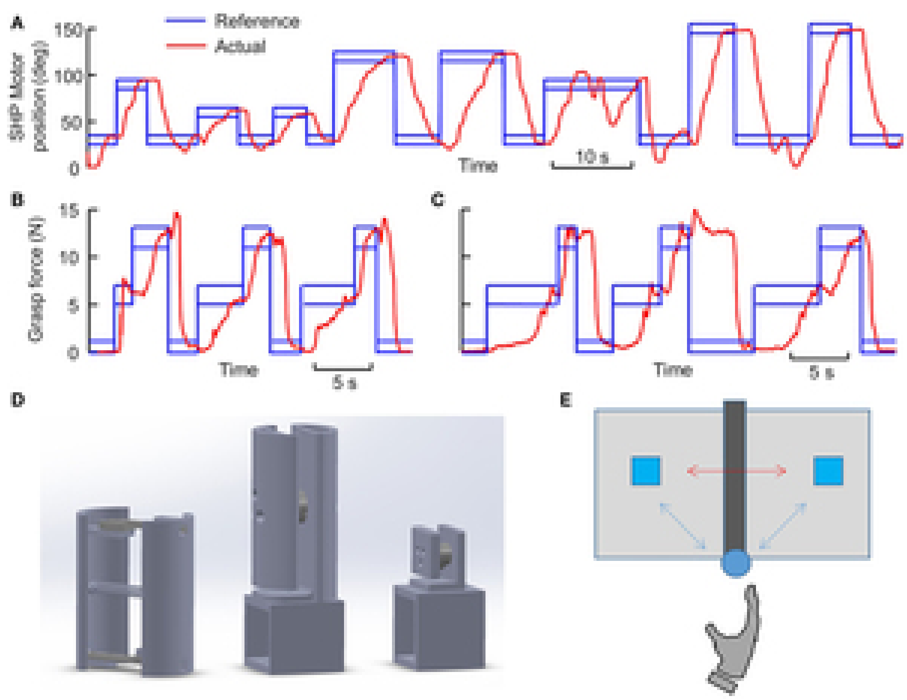
Article #12 (Patent) Notes:

Source Title	“Mobile prosthetic apparatus for disabled four-legged animals”
Source citation (APA Format)	Parkes, Lincoln J. (Oxford, MD) 2004 Mobile prosthetic apparatus for disabled four-legged animals United States PARKES LINCOLN J. 6820572 https://www.freepatentsonline.com/6820572.html
Original URL	https://www.freepatentsonline.com/6820572.html
Source type	Patent
Keywords	Animal, prosthetic, disabled
Summary of key points (include methodology)	One style of prosthetics for pets uses wheels, similarly to a wheelchair. The back wheels are fixed while the front wheels are omni wheels. The animal goes “in” the prosthetic,resting upon a chest strap.
Research Question/Problem/ Need	What animal prosthetic devices are patented?
Important Figures	
Notes	1. Hindquarters: hind legs 2. Degenerative: progressive disease 3. Torsion: twisting of an object due to torque 4. Shoulder yoke:

	5.  6. Unitary: singular
Cited references to follow up on	N/A
Follow up Questions	1. Is this cheaper for owners? 2. What are current design flaws? 3. How does this limit mobility? 4.

Article #13 Notes:

Source Title	"Improving Fine Control of Grasping Force during Hand–Object Interactions for a Soft Synergy-Inspired Myoelectric Prosthetic Hand"
Source citation (APA Format)	Fu, Qiushi, and Marco Santello. "Improving Fine Control of Grasping Force during Hand–Object Interactions for a Soft Synergy-Inspired Myoelectric Prosthetic Hand." *Frontiers in Neurorobotics*, vol. 11, 2018, https://doi.org/10.3389/fnbot.2017.00071.
Original URL	https://www.proquest.com/docview/2294009002?accountid=29120&pq-origsite=primo
Source type	Science Journal
Keywords	Hand, prosthetic
Summary of key	Hand prosthetics are critical to restoring people's independence after

points (include methodology)	getting an amputation. However, current commercial prosthetic hands do not mimic human hands well. By studying human neuromuscular systems, the researchers identified that grasping common objects could be related to some finger joint coordination patterns.
Research Question/Problem/ Need	How can prosthetic hands emulate human hands more effectively?
Important Figures	 
Notes	Postural: relating to the posture or position of the body Synergies: interaction of 2 or more things Neuromuscular: including a wide range of diseases

	Electromyogram: a test used to record the electrical activity of muscles Mechano Tactile: a neural end organ that responds to mechanical stimulus Haptic: relating to the sense of touch
Cited references to follow up on	Fani, S., Bianchi, M., Jain, S., Pimenta Neto, J. S., Boege, S., Grioli, G., et al. (2016). Assessment of myoelectric controller performance and kinematic behavior of a novel soft synergy-inspired robotic hand for prosthetic applications. *Front. Neurorobot.* 10:11. doi:10.3389/fnbot.2016.00011
Follow up Questions	1. Is there a critical limb like a hand in small animals? 2. Can this technology be implemented in pediatric prosthetics? 3. Are there alternatives/replacements to myoelectric sensors?

Article #14 Notes:

Source Title	**"A Motion Analysis Protocol for Kinematic Assessment of Poly-Articulated Prosthetic Hands With Cosmetic Gloves"**
Source citation (APA Format)	Cutti, A.G., Cordella, F., D'Amico, G., Sacchetti, R., Davalli, A., Guglielmelli, E. and Zollo, L. (2017), A Motion Analysis Protocol for Kinematic Assessment of Poly-Articulated Prosthetic Hands With Cosmetic Gloves. Artificial Organs, 41: E337-E346. https://doi.org/10.1111/aor.13006
Original URL	https://onlinelibrary.wiley.com/doi/full/10.1111/aor.13006
Source type	Science Journal
Keywords	Hands, prosthetics
Summary of key points (include methodology)	Currently, prosthetics must be customized to clients based on many parameters. Researchers aimed to find an optimal motion analysis method to measure kinematics of hands, even ones covered with cosmetic gloves. Cosmetic gloves can decrease functionality of prosthetics but by implementing myoelectric sensors, functionality was able to be analyzed. Improved should be made to increase finger flexion and motion velocity.
Research Question/Problem/	How can prosthetic hands emulate human hands more effectively?

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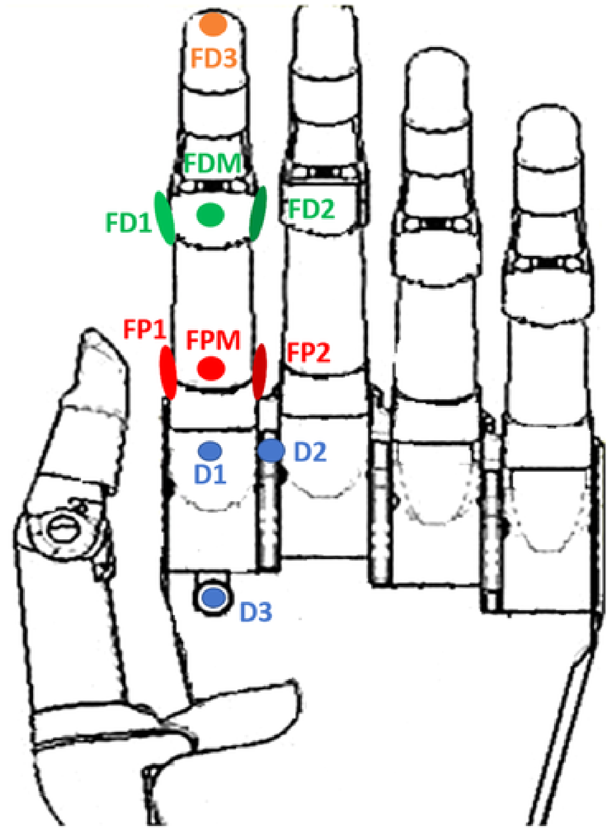
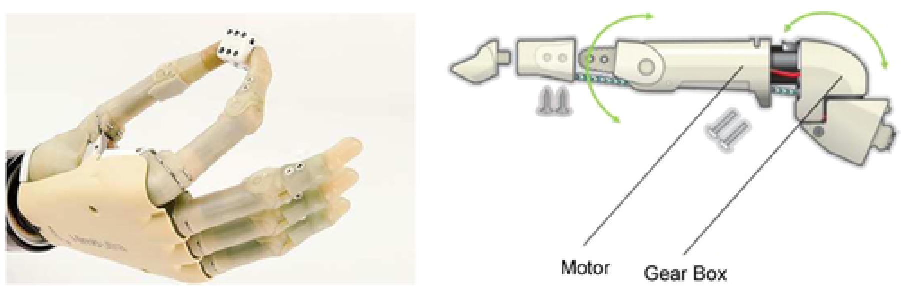
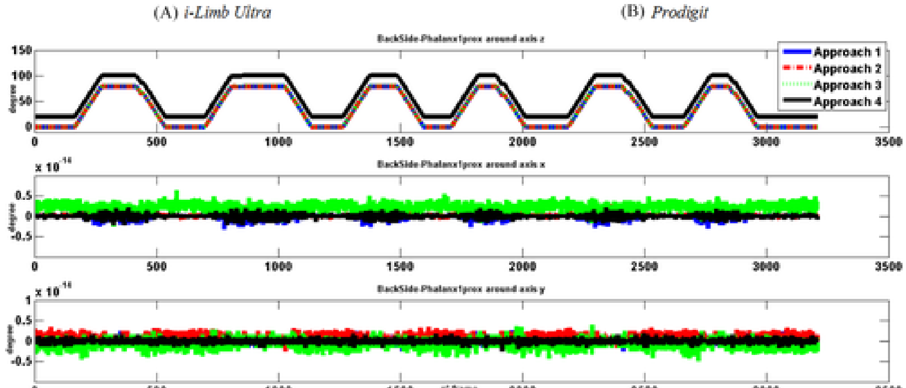




(A) i-Limb Ultra (B) Prodigit


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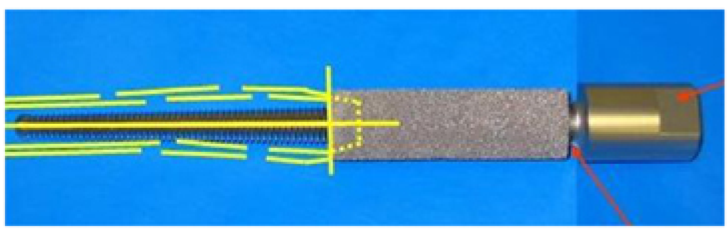
Notes	Polyarticular: involving multiple joints Polyvinyl chloride: high strength thermoplastic Hand dorsum: back of the hand Articular matrix: A matrix comprised of multiple cell types, primarily collagen, proteoglycans, and h20 molecules
Cited references to follow up on	Formica D, Zollo L, Guglielmelli E. Torque-dependent compliance control in the joint space of an operational robotic machine for motor therapy. *Proceedings of the 2005 IEEE 9th International Conference on Rehabilitation Robotics*. Chicago, IL: IEEE, 2005;341–4. Smit G, Plettenburg DH. Comparison of mechanical properties of silicone and PVC (polyvinylchloride) cosmetic gloves for articulating hand prostheses. *J Rehabil Res Dev* 2013; 50: 723– 32. Appendino S, Ambrosio EP, Chen FC, Pescarmona F. Effects of EVA glove on hand performance. *Conference on Environmental Systems*. 2011; https://doi.org/10.2514/6.2011-5085. Cerveri P, De Momi E, Lopomo N, Baud-Bovy G, Barros RML, Ferrigno G. Finger kinematic modeling and real-time hand motion estimation. *Ann Biomed Eng* 2007; 35: 1989– 2002.
Follow up Questions	1. Are cosmetic limbs used in other prosthetics? 2. Are cosmetic limbs more for function or aesthetic? 3. Would cosmetic limbs help to preserve the dexterity of prosthetics?

Article #15 Notes:

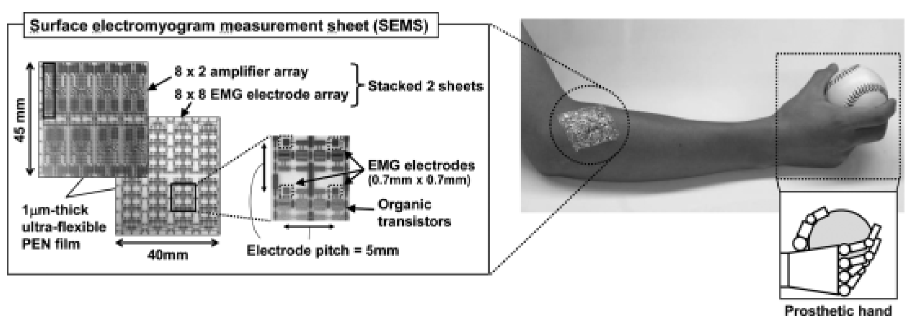
Source Title	“Transcutaneous Tibial Implants: A Surgical Procedure for Restoring Ambulation After Amputation of the Distal Aspect of the Tibia in a Dog”
Source citation (APA Format)	DRYGAS, K.A., TAYLOR, R., SIDEBOTHAM, C.G., HUGATE, R.R. and MCALEXANDER, H. (2008), Transcutaneous Tibial Implants: A Surgical

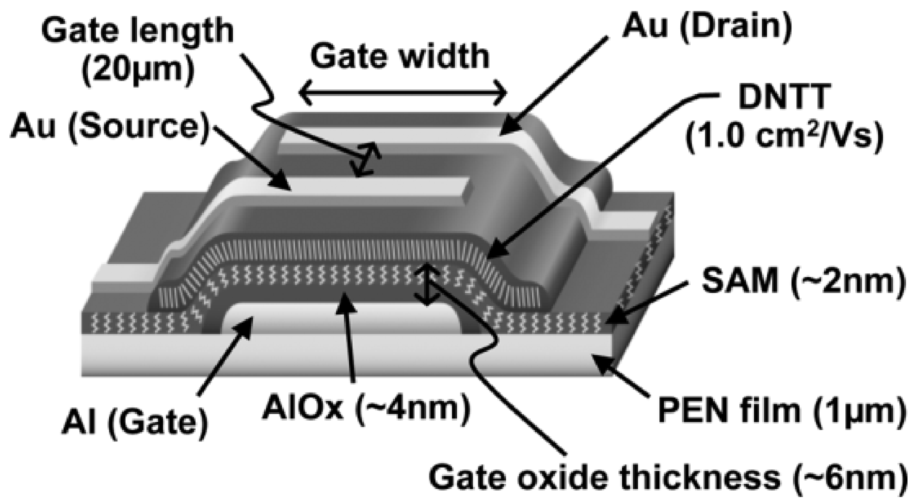
	Procedure for Restoring Ambulation After Amputation of the Distal Aspect of the Tibia in a Dog. Veterinary Surgery, 37: 322-327. https://doi.org/10.1111/j.1532-950X.2008.00384.x
Original URL	https://onlinelibrary.wiley.com/doi/full/10.1111/j.1532-950X.2008.00384.x?casa_token=HZFwtdMz9lAAAAAA%3A8Ri6nMnqeFzUFIA8Cwf9CrRZCnobR9_GbkyICetPy7UjRlIErDxi5ZpnpuA0foj3cM8xONvo84qASNrJ
Source type	Science Journal
Keywords	Veterinary, orthotics, prosthetics, tibia
Summary of key points (include methodology)	A four year old Siberian husky lost her two back limbs. So, tibial prosthetics were implanted partially within her leg. This experiment was to simulate how prosthetics could be implanted after bilateral amputations in small animals. The client was monitored for two years, and by the end, her prosthetic implants permitted her to regain locomotion.
Research Question/Problem/ Need	What prosthetics are available for dogs?
Important Figures	

	
Notes	Tomographic: an image of a cross section of a body obtained by x-rays or an ultrasound Stereolithographic: A form of 3D printing (layer by layer) Aseptic: without bacteria, viruses or other microorganisms Pressure necrosis: injury caused by too tight collars Dodecahedral: 3D shape, a polyhedron with 12 flat faces
Cited references to follow up on	Gordon WJ, Conzemius MG, Birdsall E, *et al*: Chondroconductive potential of tantalum trabecular metal. *J Biomed Mater Res* 75B: 229–233, 2005 Gangjee T: Species related differences in percutaneous wound healing. *Ann Biomed Eng* 13: 451– 467, 1985 Brånemark R, Ohrnell LO, Skalak R, *et al*: Biomechanical characterization of osseointegration: *an experimental in vivo investigation in the beagle dog*. J Orthop Res 16: 61– 69, 1998 Levy SW: Amputees: *skin problems and prostheses*. Contin Med Educ 55: 297– 301, 1995
Follow up Questions	1. How much does this cost? 2. Would a dog's breed impact their suitability for a prosthetic? 3. How can problems for animal prosthetics be identified (since animals can't talk)?

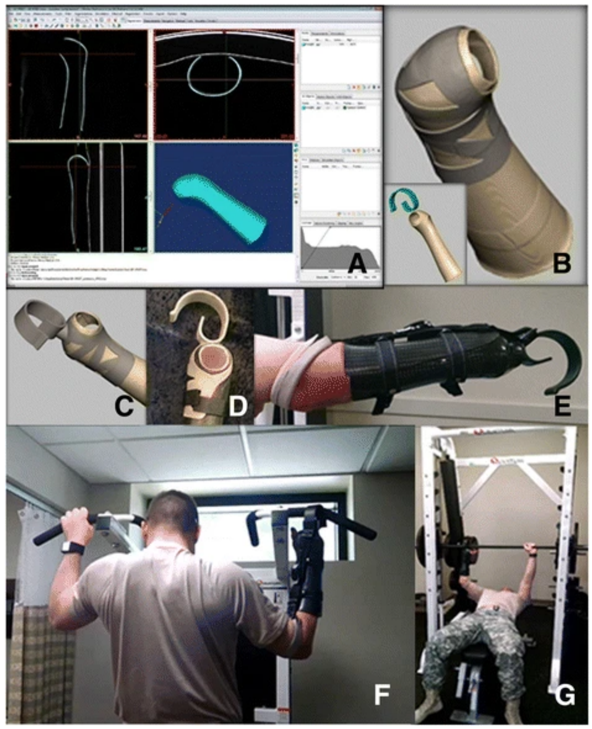
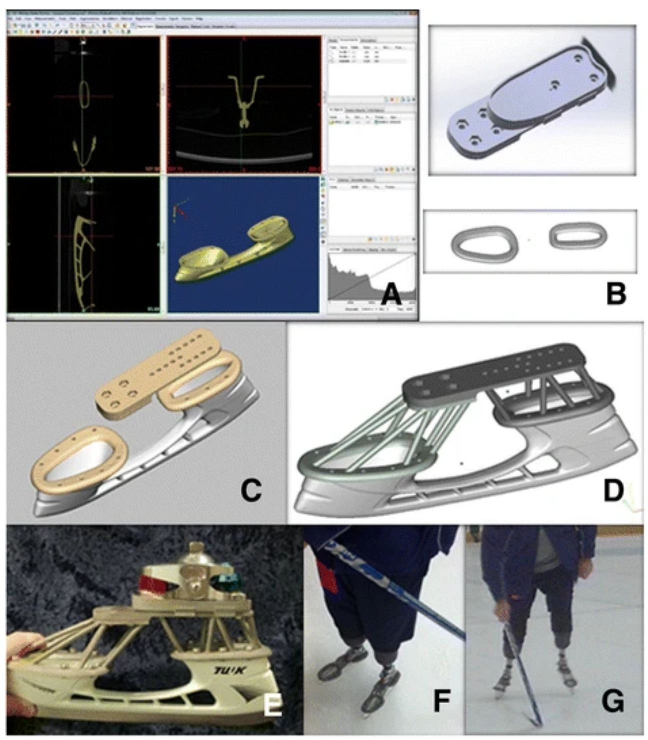
Article #16 Notes:

Source Title	“1μm-Thickness Ultra-Flexible and High Electrode-Density Surface Electromyogram Measurement Sheet With 2 V Organic Transistors for Prosthetic Hand Control”
Source citation (APA Format)	H. Fuketa *et al*., "1 μm-Thickness Ultra-Flexible and High Electrode-Density Surface Electromyogram Measurement Sheet With 2 V Organic Transistors for Prosthetic Hand Control," in *IEEE Transactions on Biomedical Circuits and Systems*, vol. 8, no. 6, pp. 824-833, Dec. 2014, doi: 10.1109/TBCAS.2014.2314135.
Original URL	https://ieeexplore.ieee.org/document/6828792
Source type	Science Journal
Keywords	Hand, prosthetics, problems
Summary of key points (include methodology)	An optimized circuit board was created by these scientists in order to maximize measurements of a prosthetic hand. It uses surface EMG electrodes to fulfill its three main goals: mechanical flexibility, signal strength, and high electrode density. The scientists combined multiple (DSA, SAC) circuit concepts/ patterns in order to optimize this specific board. It measures voltage waveform which is made by skeletal muscles touching skin.
Research Question/Problem/ Need	What are the main electrical components of hand prosthetics?
Important Figures	

	
Notes	Electromyogram: Monolayer: pseudo-CMOS: Ink-jet: Monte- Carlo Simulation:
Cited references to follow up on	A. Merlo and C. Isabella, "Technical aspects of surface electro myography for clinicians", *Open Rehabil. J.*, vol. 3, pp. 98-109, 2010.
Follow up Questions	1. What sensors are the most important? 2. What sensors would be best for animal prosthetics? 3. Where would be the ideal placement for sensors on an animal prosthetic?

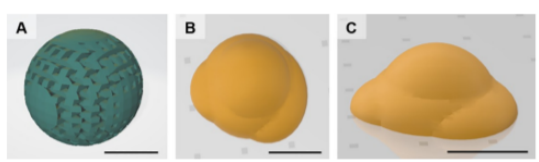
Article #17 Notes:

Source Title	"Using computed tomography and 3D printing to construct custom prosthetics attachments and devices"
Source citation (APA Format)	Liacouras, P.C., Sahajwalla, D., Beachler, M.D. *et al.* Using computed tomography and 3D printing to construct custom prosthetics attachments and devices. *3D Print Med* 3, 8 (2017). https://doi.org/10.1186/s41205-017-0016-1
Original URL	https://threedmedprint.biomedcentral.com/articles/10.1186/s41205-017-0016-1#Abs1
Source type	Science Journal
Keywords	3D printing, prosthetics, medicine
Summary of key points (include methodology)	As time progresses, 3D printing technology is becoming more advanced and more common in prosthetics. 3D printing mechanical components has many benefits including being cost efficient, fast, and easily customizable. This article talked about how three custom prosthetics, for hockey, weight lifting, and drinking wine were designed and manufactured. First, the engineer met with the client to establish the main goals for the prosthetic. Then, it was designed with CAD. The prosthetics were then 3D printed, and certain parts were made using metal alloys.
Research Question/Problem/ Need	How is 3D printing used in current prosthetics?

Important Figures	 
Notes	Computed tomography: Optical image capture: MIMICS Medical v17: Lab Putty: Titanium alloy:

Cited references to follow up on	Gretsch KF, Lather HD, Peddada KV, Deeken CR, Wall LB, Goldfarb CA. Development of novel 3D-printed robotic prosthetic for transradial amputees. Prosthetics Orthot Int. 2016;40(3):400–3. Watanabe T, Hatakeyama T, Tomiita M. Improving assistive technology service by using 3D printing: three case studies. Stud Health Technol Inform. 2015;217:1047–52. Herbert N, Simpson D, Spence WD, Ion W. A preliminary investigation into the development of 3-D printing of prosthetic sockets. J Rehabil Res Dev. 2005;42(2):141–6.
Follow up Questions	1. How common are completely 3D printed prosthetics? 2. Are they as durable as ones made with other materials? 3. Have these techniques been applied to veterinary medicine?

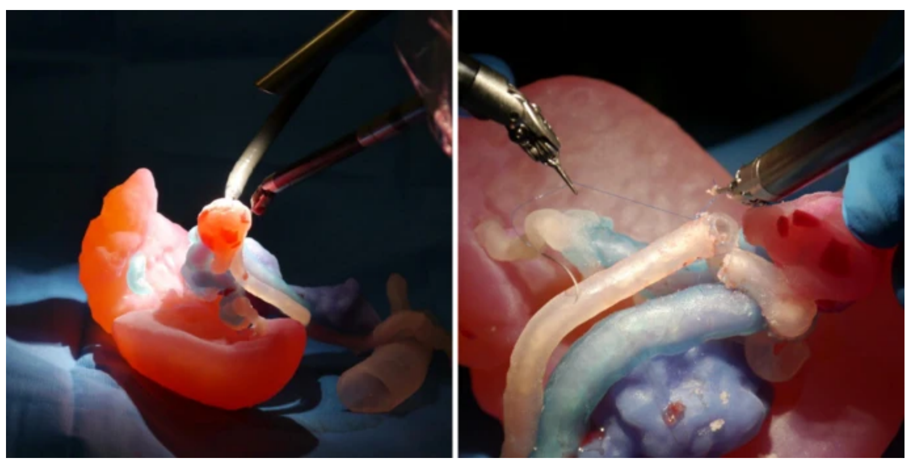
Article #18 Notes:

Source Title	"Custom-made artificial eyes using 3D printing for dogs: A preliminary study"
Source citation (APA Format)	Park, S., An, J., Kwon, H., Choi, S., Lim, K., Kwak, H., Hussein, K. H., Woo, H., & Park, K. (2020). Custom-made artificial eyes using 3D printing for dogs: A preliminary study. *PloS One, 15*(11), 1. http://dx.doi.org/10.1371/journal.pone.0242274
Original URL	https://www.proquest.com/docview/2463099708?accountid=29120&parentSessionId=1elApW3vJ7kxGvabRE2Kurht1KqX0LVv2pIUhJBPLp4%3D&pq-origsite=primo
Source type	Science Journal
Keywords	3D printing, dogs, artificial
Summary of key points (include methodology)	Various incurable eye diseases in dogs lead to the need of surgically removing the eye. Since eye prosthetics must be very custom to suit diverse dogs, ocular implants are not used commonly. In this study, custom artificial eyes were designed for beagles using CAD, then printed and implanted. The dogs were observed for 6 months and the 3D printed prosthetic was very successful. The prosthetic eyes were good fits for the dogs as well as stimulated useful tissue growth.
Research Question/Problem/ Need	What are current applications of 3D printing in veterinary medicine?
Important Figures	 **Fig 2. Three-dimensional model designed using computer-aided design.** Orbital implant (A), Ocular prosthesis; sky view (B) and side view (C). Bar = 1 cm. https://doi.org/10.1371/journal.pone.0242274.g002
Notes	Ocular: Orbital implant: Ultrasonography: Polycaprolactone: Hydroxyapatite:

	Biocompatible:
Cited references to follow up on	Pugliese L, Marconi S, Negrello E, Mauri V, Peri A, Gallo V, et al. The clinical use of 3D printing in surgery. Updates Surg. 2018; 70: 381–388. https://doi.org/10.1007/s13304-018-0586-5 Zhang H, Mao X, Du Z, Jiang W, Han X, Zhao D, et al. Three dimensional printed macroporous polylactic acid/hydroxyapatite composite scaffolds for promoting bone formation in a critical-size rat calvarial defect model. Sci Technol Adv Mater. 2016; 17: 136–148. https://doi.org/10.1080/14686996.2016
Follow up Questions	1. What are common roadblocks / mistakes? 2. How can I minimize roadblocks in my project? 3. What are other 3D printing applications in veterinary medicine?

Article #19 Notes:

Source Title	"The clinical use of 3D printing in surgery"

Source citation (APA Format)	Pugliese, L., Marconi, S., Negrello, E. *et al.* The clinical use of 3D printing in surgery. *Updates Surg* 70, 381–388 (2018). https://doi.org/10.1007/s13304-018-0586-5
Original URL	https://link.springer.com/article/10.1007%2Fs13304-018-0586-5
Source type	Science Journal
Keywords	3D printing, medicine, clinical
Summary of key points (include methodology)	In addition to being used in implants and prosthetics, 3D printing technology is being used in clinical aspects of medicine as well. By using radiological imaging on patients, doctors are able to obtain precise scans of body parts. Which can be helpfully modeled in 2D with CAD and in 3D with 3D printing. Surgical simulators are also being increasingly commonly made using 3D printing which is very beneficial for medical students.
Research Question/Problem/ Need	How is 3D printing used in medicine today?
Important Figures	
Notes	Intraoperative: Manifold: Volumetric: magnetic resonance (MRI): Chromatic yield:
Cited references to follow up on	Martelli N, Serrano C, van den Brink H et al (2016) Advantages and disadvantages of 3-dimensional printing in surgery: a systematic review. Surgery 159(6):1485–1500

Follow up Questions	1. What kind of plastic is optimal for medical 3D printing? 2. Is “recreational” medical 3D printing common? 3. How often are replacements made/ needed?

Article #20 Notes:

Source Title	Three dimensional printed macroporous polylactic acid/hydroxyapatite composite scaffolds for promoting bone formation in a critical-size rat calvarial defect model
Source citation (APA Format)	Haifeng Zhang, Xiyuan Mao, Zijing Du, Wenbo Jiang, Xiuguo Han, Danyang Zhao, Dong Han & Qingfeng Li (2016) Three dimensional printed macroporous polylactic acid/hydroxyapatite composite scaffolds for promoting bone formation in a critical-size rat calvarial defect model, Science and Technology of Advanced Materials, 17:1, 136-148, DOI: 10.1080/14686996.2016.1145532
Original URL	https://www.tandfonline.com/doi/full/10.1080/14686996.2016.1145532
Source type	Science Journal
Keywords	3D printing, medicine, veterinary
Summary of key points (include methodology)	Three bone implants for rats were made using three different materials, one being 3D printed. The scientists evaluated the rats 4 weeks and 8 weeks after the implant surgery. The 3D printed implant was accepted very well by the rat’s body, and did not cause any problems such as inflammation. Results from this experiment told scientists that bone grafts can be made using 3D printed plastic safely.
Research Question/Problem/	How is 3D printing used in medicine today?

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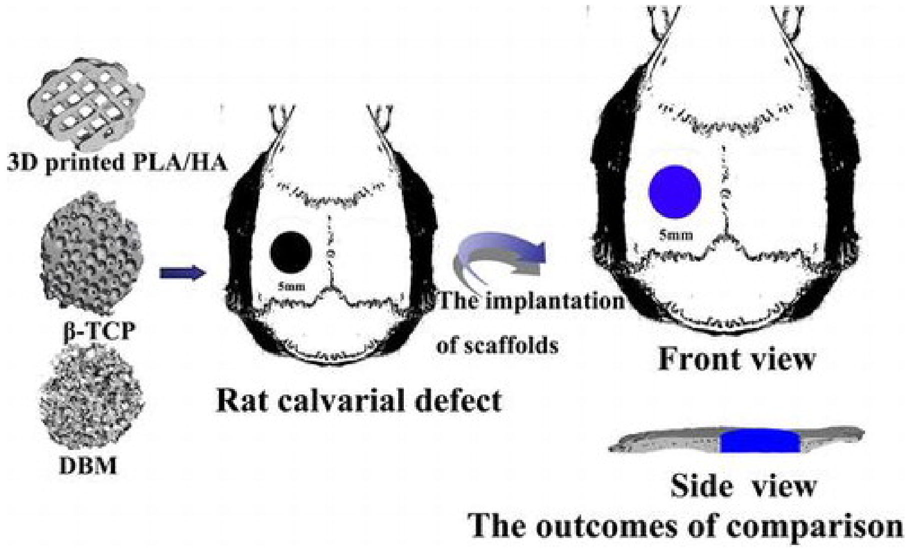

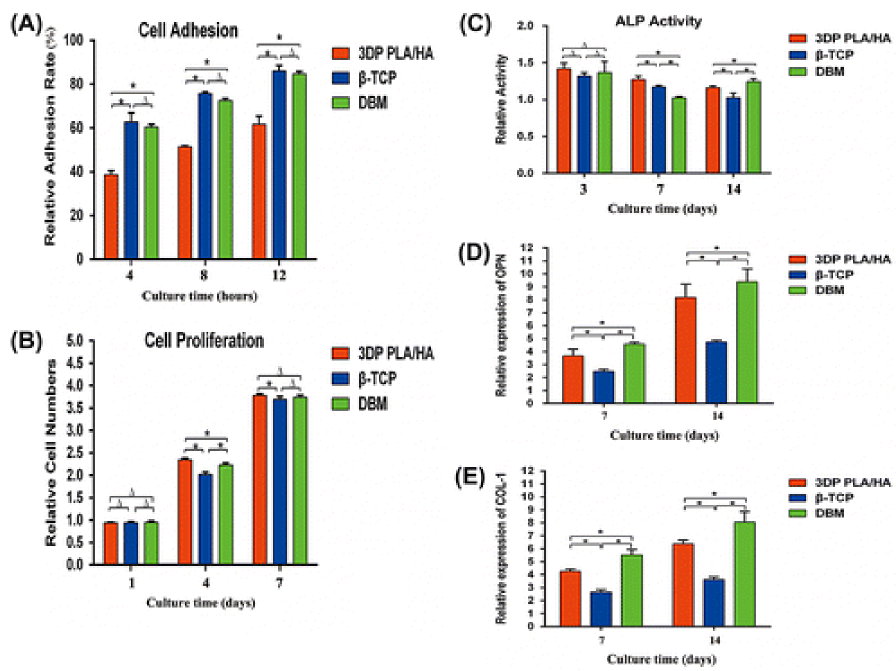

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<tr><td>Notes</td><td>Osteogenic:
Biodegradation:
Resorbable:
alkaline phosphatase activity:
autologous bone grafts:</td></tr>
<tr><td>Cited references to follow up on</td><td>Bandyopadhyay A, Bose S, Das S. 3D printing of biomaterials. MRS Bulletin. 2001;25:273–80.</td></tr>
</table>

Follow up Questions	1. What testing methods would be most effective with dogs? 2. How can comfort be quantified? 3. Can plastic cause skin irritation / allergies with dogs?

Article #21 Notes:

Source Title	
Source citation (APA Format)	
Original URL	
Source type	Science Journal
Keywords	
Summary of key points (include methodology)	
Research Question/Problem/ Need	
Important Figures	
Notes	
Cited references to follow up on	
Follow up Questions	

Article #22 Notes:

Source Title	

Source citation (APA Format)	
Original URL	
Source type	Science Journal
Keywords	
Summary of key points (include methodology)	
Research Question/Problem/ Need	
Important Figures	
Notes	
Cited references to follow up on	
Follow up Questions	