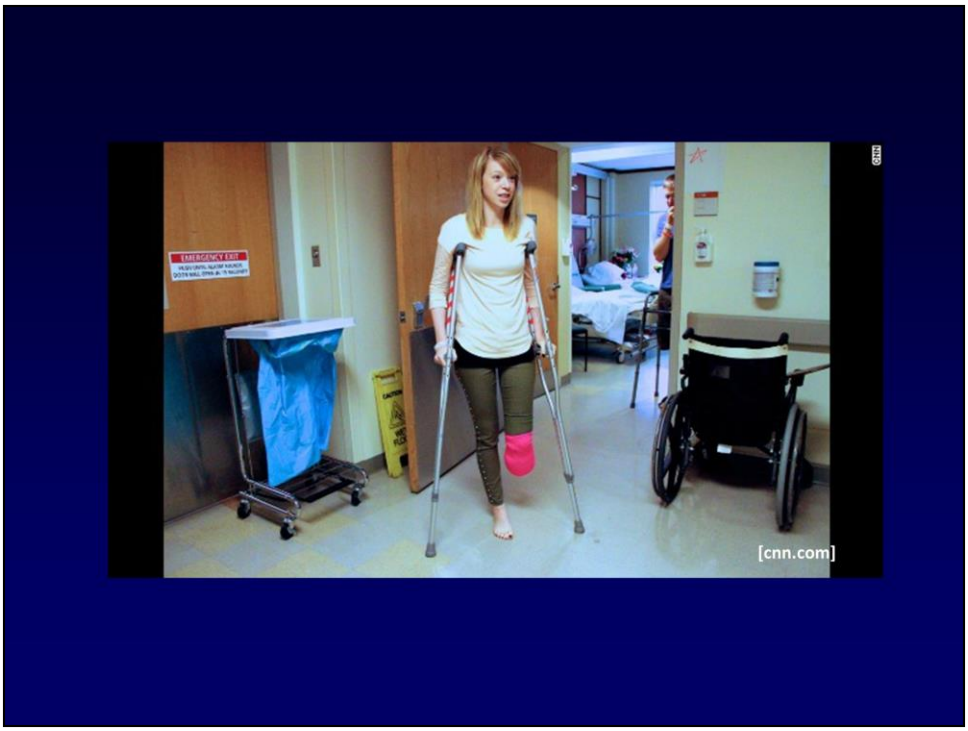

Neil Tufano



I would like to start off today with a brief story. This is Adrianne Haslet-Davis, a ballroom dancer who lost her left leg in the Boston Marathon bombing. She is obviously disabled to an extent. As you can imagine, she became very worried about not being able to return to her passion as a dancer. But its even more than that. How about worrying about being able to walk normal? Theodoros Manfredi wrote an article for HealthGuidance in which he explained how losing a limb has just as many psychological affects as physical affects on an individual. This is why everyone in the classroom today is fortunate. We are fortunate that we have never had such thoughts about not being able to do simple, every day tasks. According to Hugh Herr, "A human being can never be broken. Humans are not disabled." Today you will learn that this is 100% true.

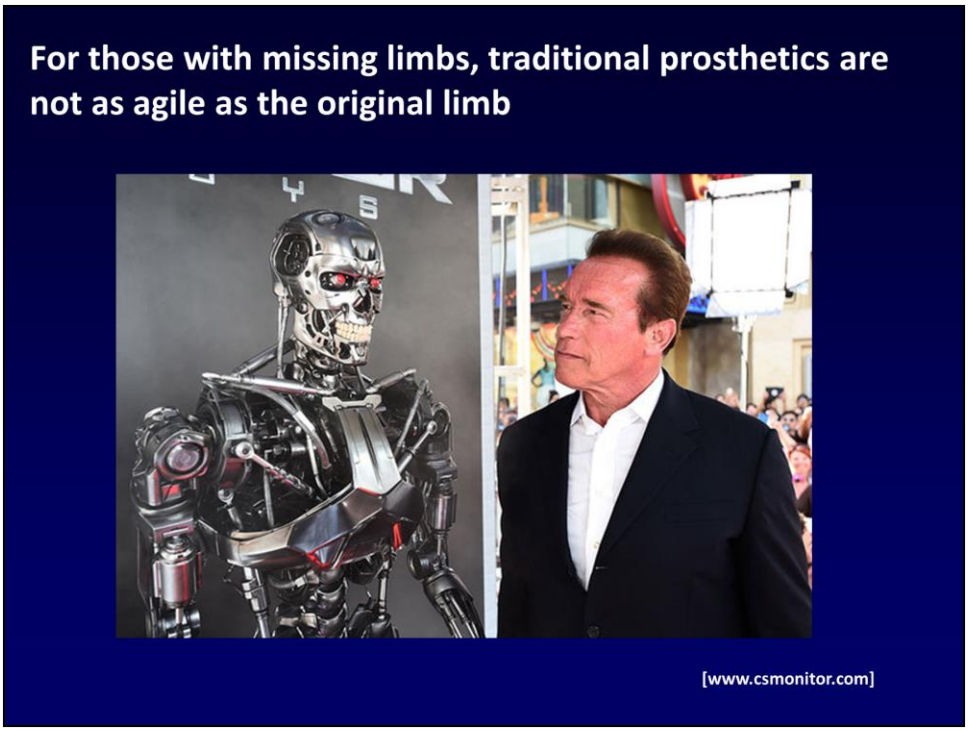
https://www.glamour.com/story/boston-marathon-bombing-survivor-adrianne-haslet-davis-i-dont-believe-everything-happens-for-a-reason



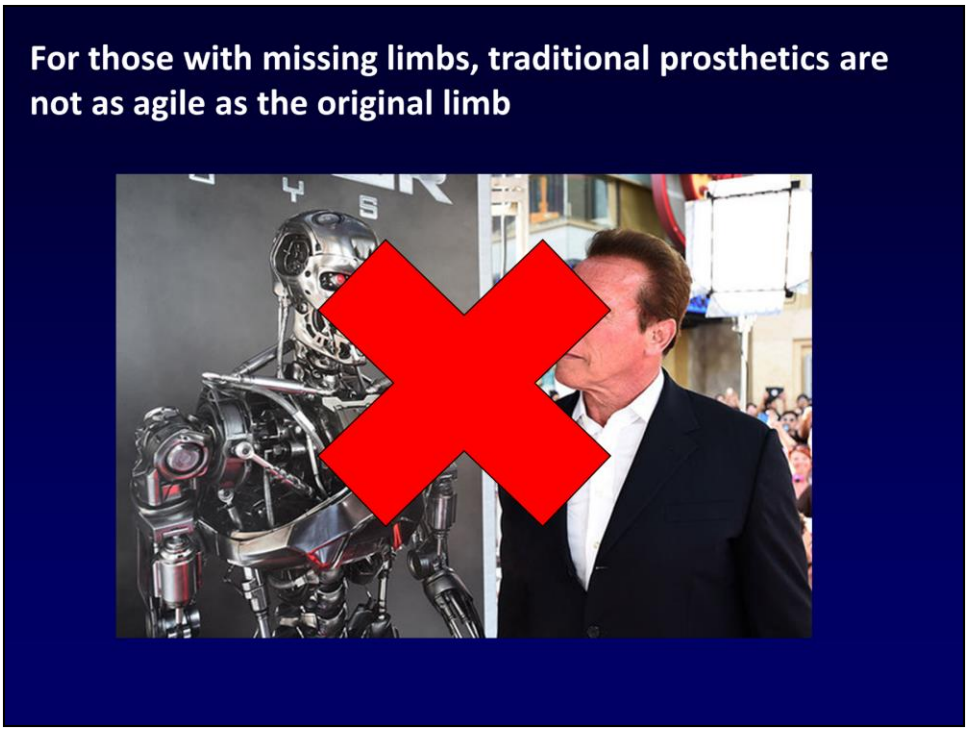
For those who don't remember, Hugh Herr is a biophysicist at MIT who lost his legs due to an ice climbing accident. He is one of the approximately 2 million people living in the US with limb loss, according to the amputee coalition. Only 12 months after the accident, he could climb the same levels he did before the accident. He actually exceeded his previous levels and climbed walls that nobody had climbed before. His friends jokingly threatened to cut their own legs off to achieve the same unfair advantage.

https://www.youtube.com/watch?v=a2z8CE2vomY

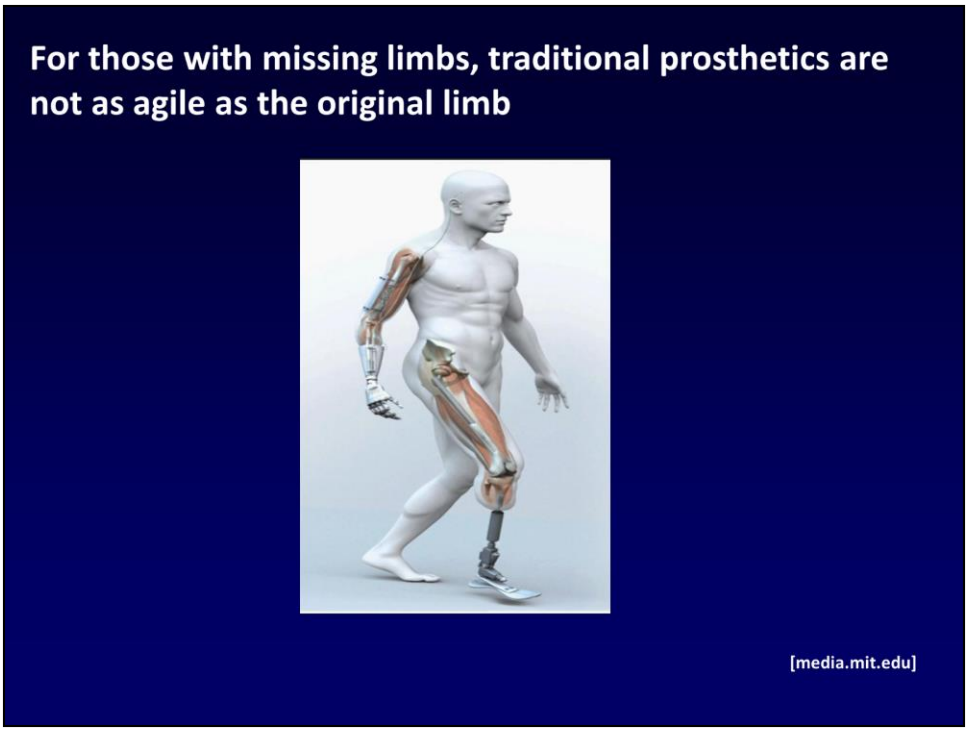
http://www.amputee-coalition.org/limb-loss-resource-center/resources-filtered/resources-by-topic/limb-loss-statistics/limb-loss-statistics/



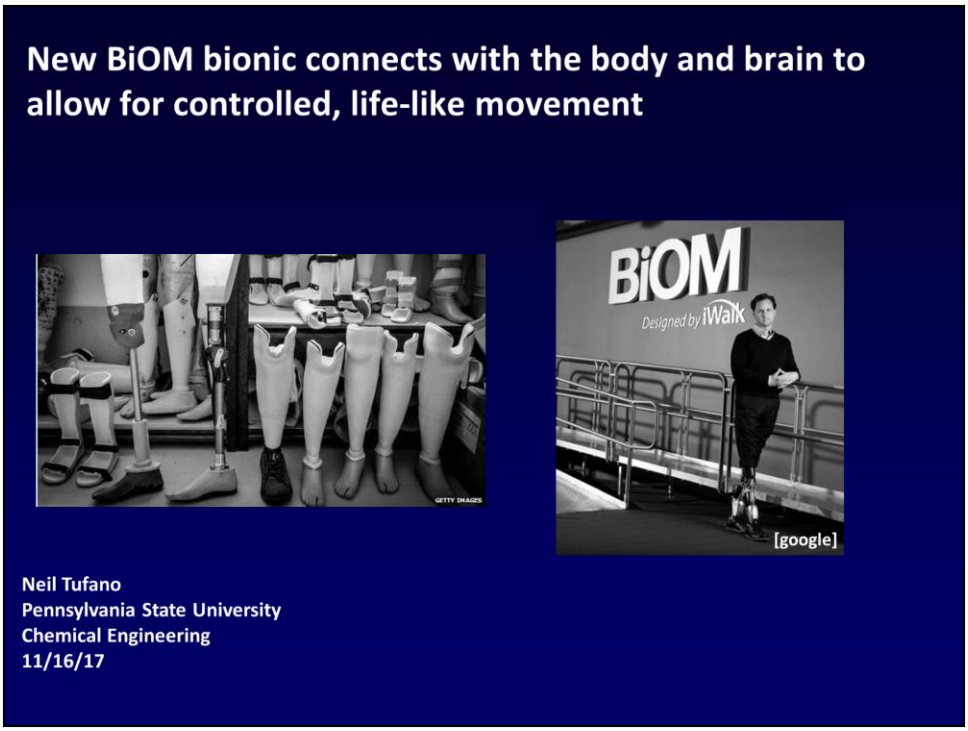
Hugh Herr says, “Technology is broken, technology is inadequate.” An example of a piece of flawed technology is the traditional prosthetic that does not allow for agile and life-like movement. What if I said that there are pieces of technology out there that are making everyday movements, such as walking or running, easier for people? I am specifically referring to exoskeletons. There are exoskeletons that attach to the body and are so efficient in movement that when a person stops using the mechanism after 40 minutes, their own biological legs feel extremely heavy and awkward. This is proof that the technology is there. If anyone has seen any of the Terminator series movies, you know that Arnold Schwarzenegger is a complex robot under realistic human skin.



I will not be talking about exoskeletons or complex robots that could take over the world. I brought this up because, believe it or not, it relates in a sense to what I will be talking about. That is a solution that will make those with limb loss appear as normal as Arnold did in those movies, even though he was a machine.

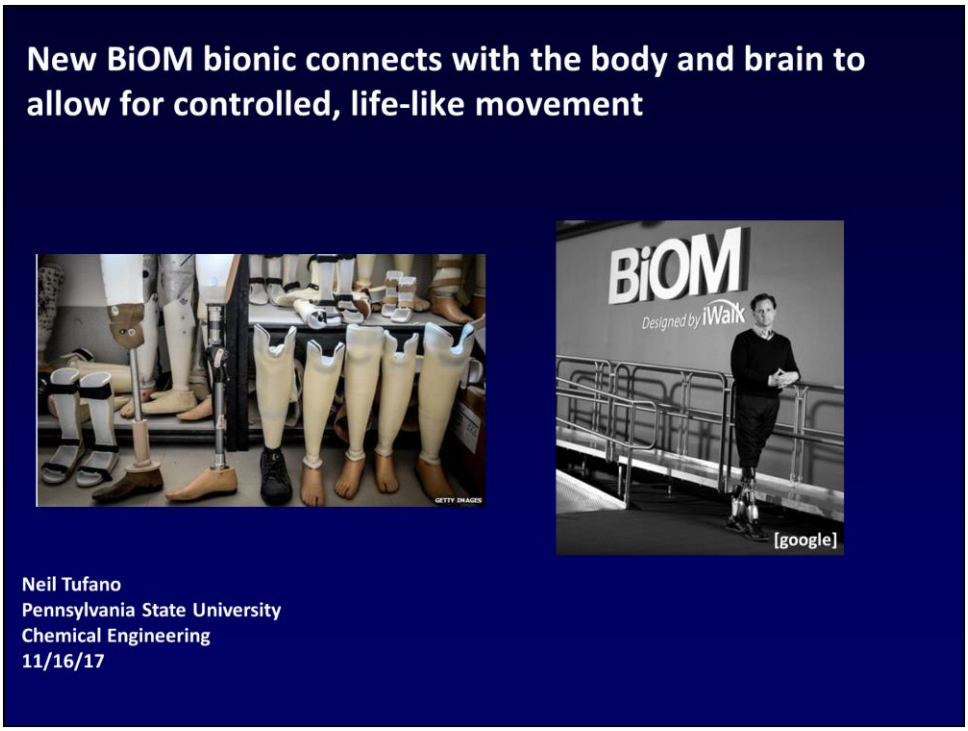


This is a more accurate visual of what I will be talking about. Specific parts of the body, or limbs, that are bionic.



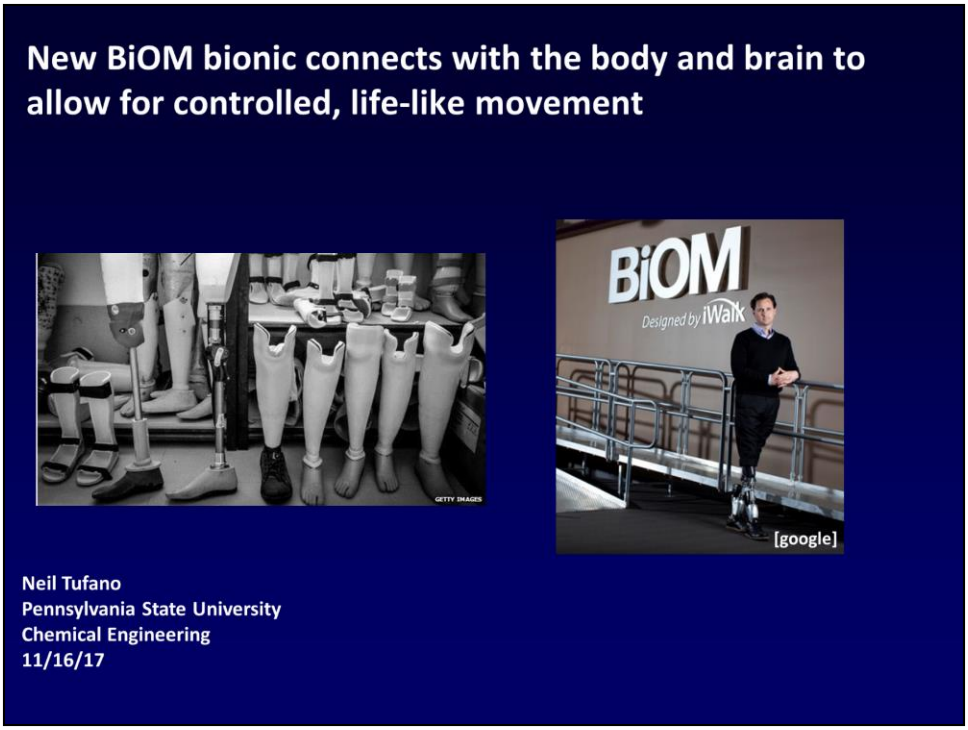
My name is Neil Tufano. I am a sophomore majoring in chemical engineering here at Penn State. Today I will be talking about a new species of bionics called the BiOM. First I will explain the procedure that follows after someone loses a limb and problems with traditional prosthetics. Then I will talk about the new BiOM bionic system that fixes all these problems and enhances the quality of life for those with limb loss. I want all of you to keep in mind that I will only be focusing on leg prosthetics and not on the physical components/materials of the bionic. I also will not talk about price because Hugh Herr is attempting to negotiate with CMS to make sure these bionics are distributed to the patients who need them. Furthermore, there is a weight and size restriction. According to BIONX, the system, as of right now, can support up to 287 pounds and can fit feet up to a size 12.

http://www.bionxmed.com/payer/the-biom-advantage/



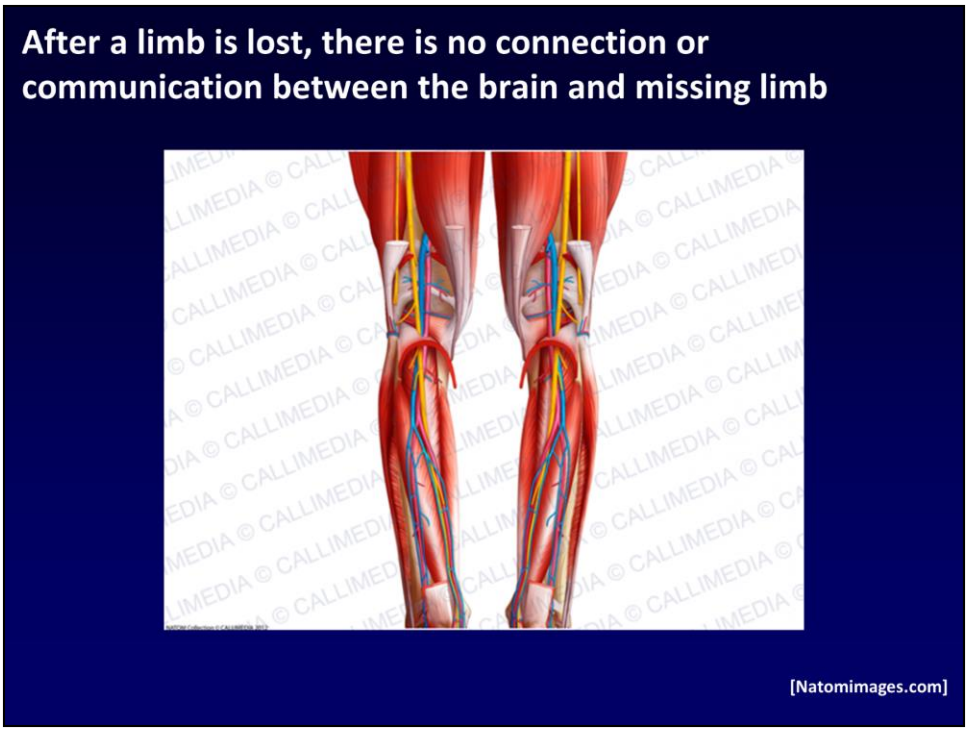
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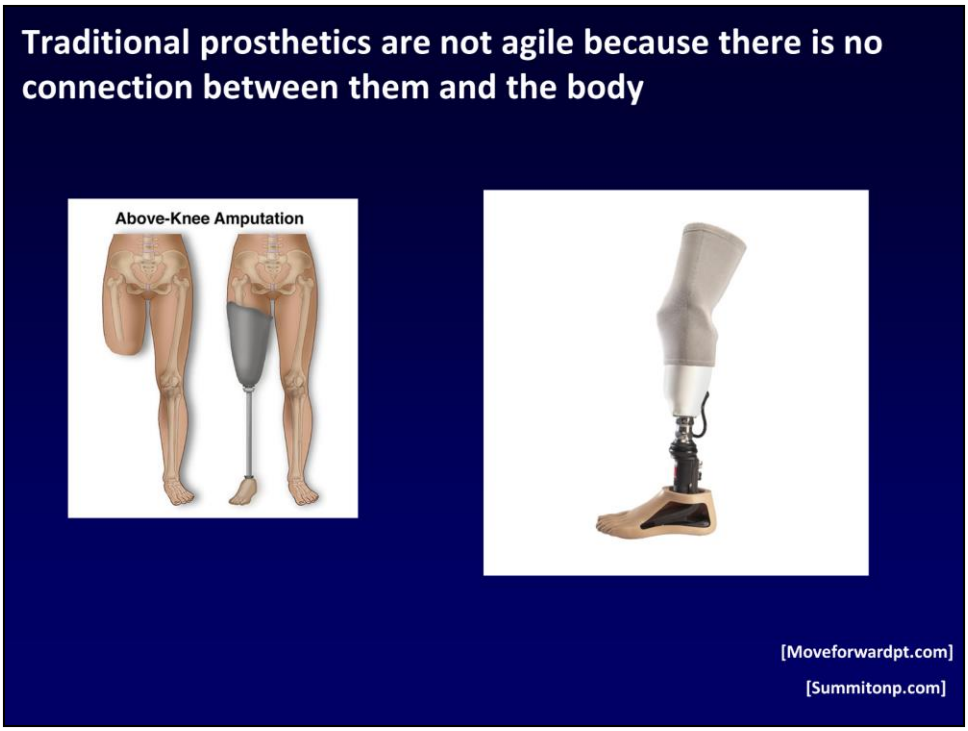
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The main problem is that after a limb is lost, there is no connection between the prosthetic and the body. This is because muscle is wrapped around the raw end of the limb, all nerve endings are buried, and the wound is stitched/covered up. As a result, signals cannot travel from the brain to the missing limb and back.

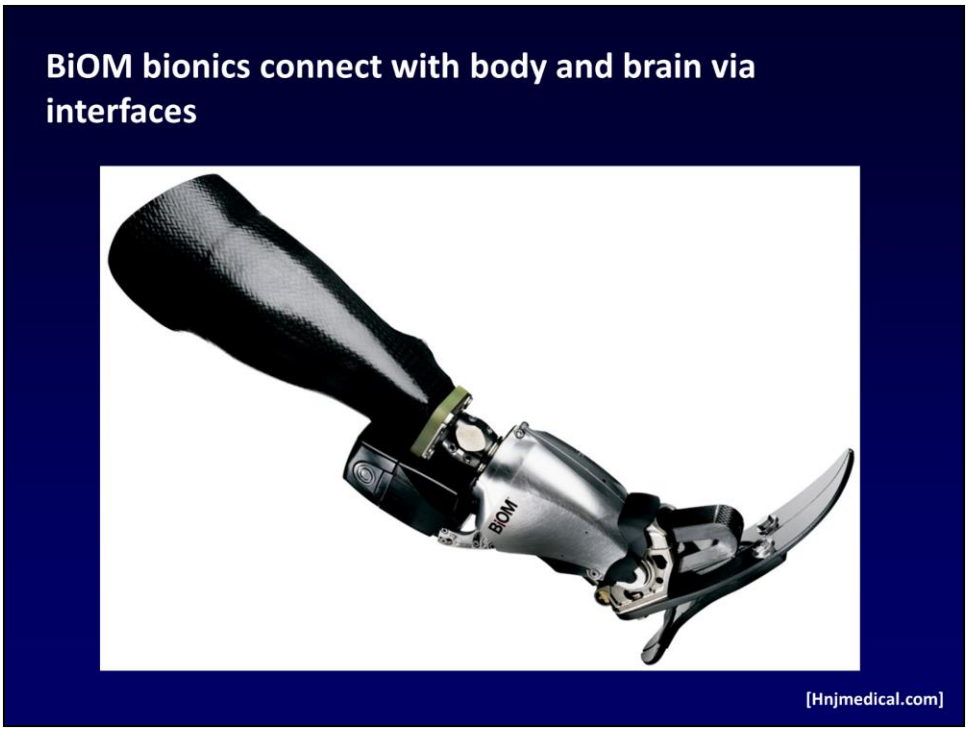
http://www.sciencemag.org/news/2017/05/new-surgical-procedure-could-lead-lifelike-prosthetic-limbs



Most prosthetic legs are passive and a result, amputees have to use about 20% more energy to walk. The most common traditional prosthetic is called the socket development. A socket is designed to fit the individual and attach like a glove to the rest of the existing limb. Older prosthetics like this cause multiple problems such as irritation, pain, and most of all an abnormality.

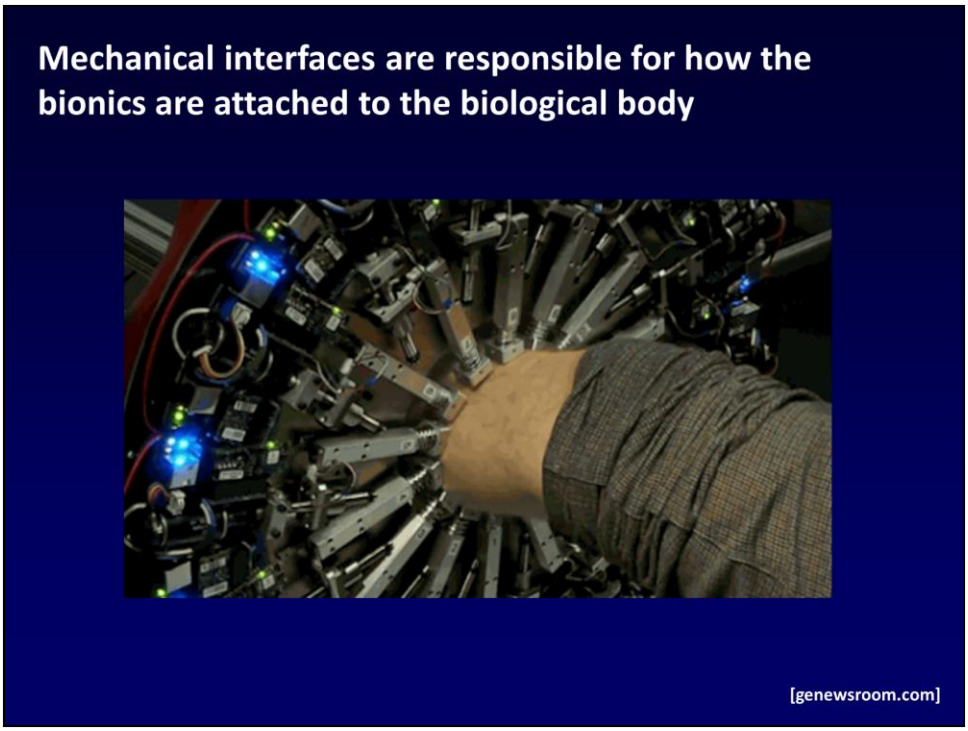
http://www.healthguidance.org/entry/15868/1/Types-of-Leg-Prosthetics.html

https://www.youtube.com/watch?v=a2z8CE2vomY



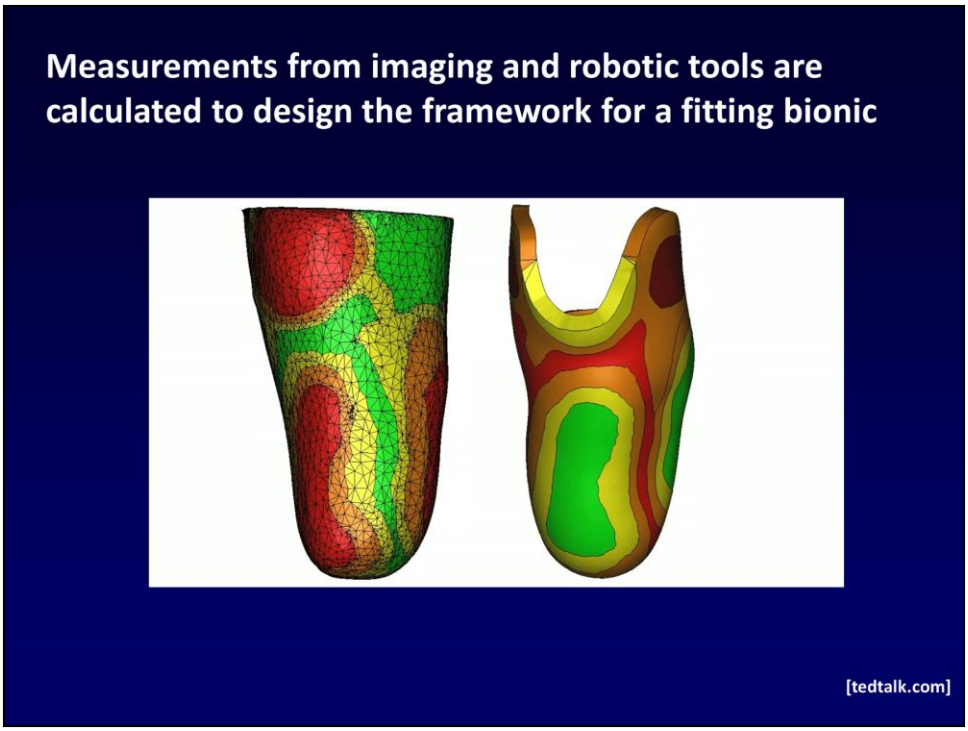
The BiOM bionic system, developed by Hugh Herr, is a new type of prosthetic that successfully connects with the body and brain via interfaces. The BiOM system also allows for precise control as well as life-like movement. I will be discussing three interfaces; mechanical, dynamic, and electrical.

https://www.ted.com/talks/hugh_herr_the_new_bionics_that_let_us_run_climb_and_dance#t-236207



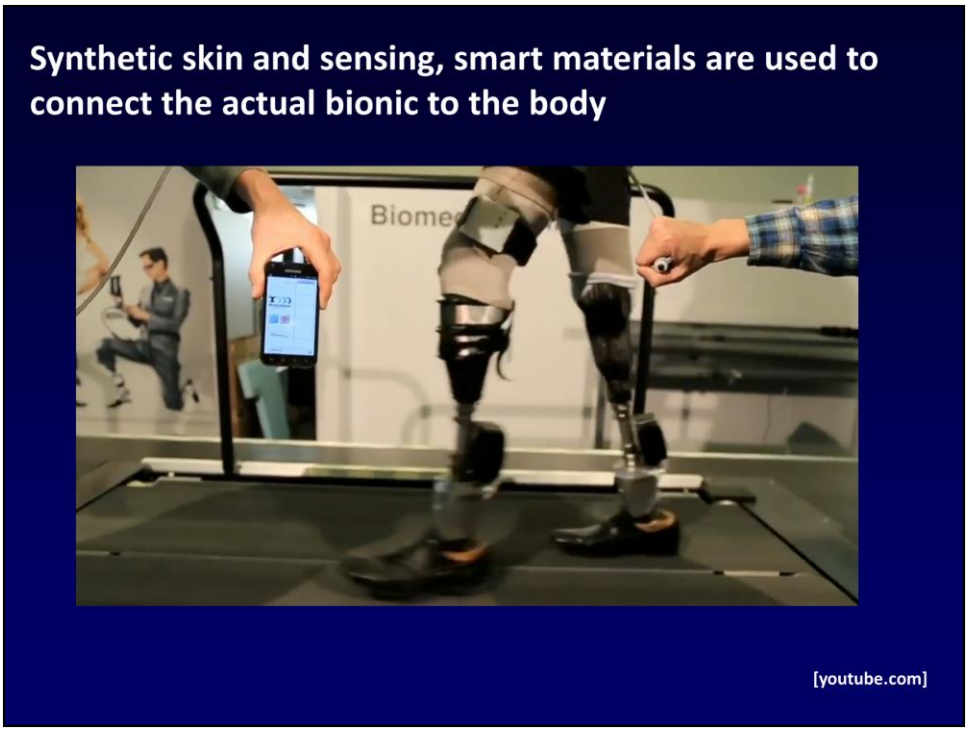
Mechanical interfaces cover how the bionic is attached to the biological body. Imaging tools such as MRI are used to make a mathematical model of the biological limb. Robotic tools (such as this 14 actuator circle) find the surface of limb, determine its shape and push on tissues to measure tissue compliances at each point.

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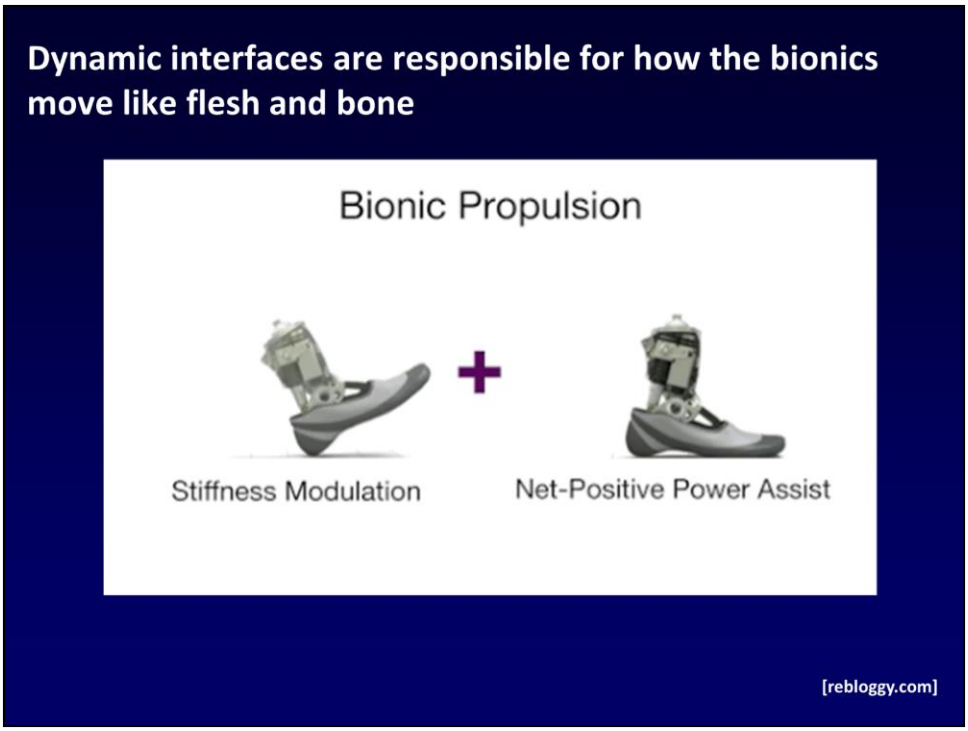
Imaging and robotic tools provide topographical data for a mathematical description. Each color on this model represents tissue compliance. This is the framework of the bionic.

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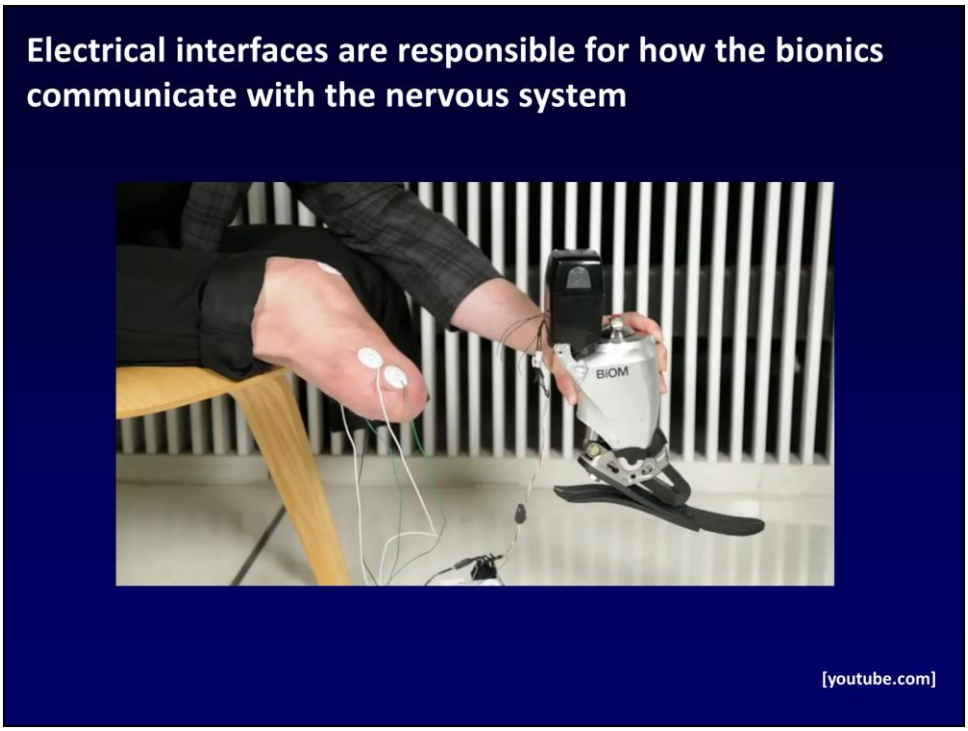
Synthetic skin is used to connect the bionic to the biological body. Where the body is stiff the synthetic skin should be soft and where the body is soft the synthetic skin should be stiff. Sensing, smart materials are imbedded into the synthetic skin to improve the connection to the body. These additions change the stiffness where need be through voltage. With zero voltage applied, the synthetic skin is floppy. After voltage is applied, it becomes stiff as a board. Notice in this video that once the voltage is applied, it appears he has more power behind each step.

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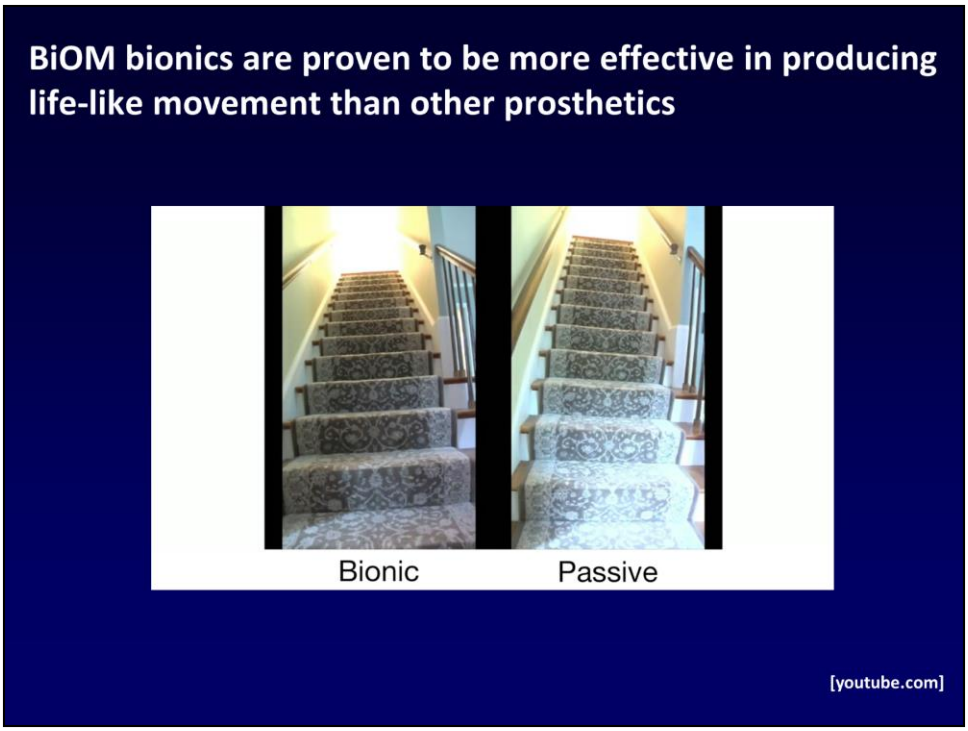
Next are dynamic interfaces which cover how the bionics move like flesh and bone. The answer to this is through a process called bionic propulsion. Once the heel hits ground, a computer system controls stiffness to absorb the shock of the limb hitting the ground. Once the bottom is flat on the ground, the bionic outputs torques and powers to lift the person into a walking stride, comparable to the role of the calf muscle.

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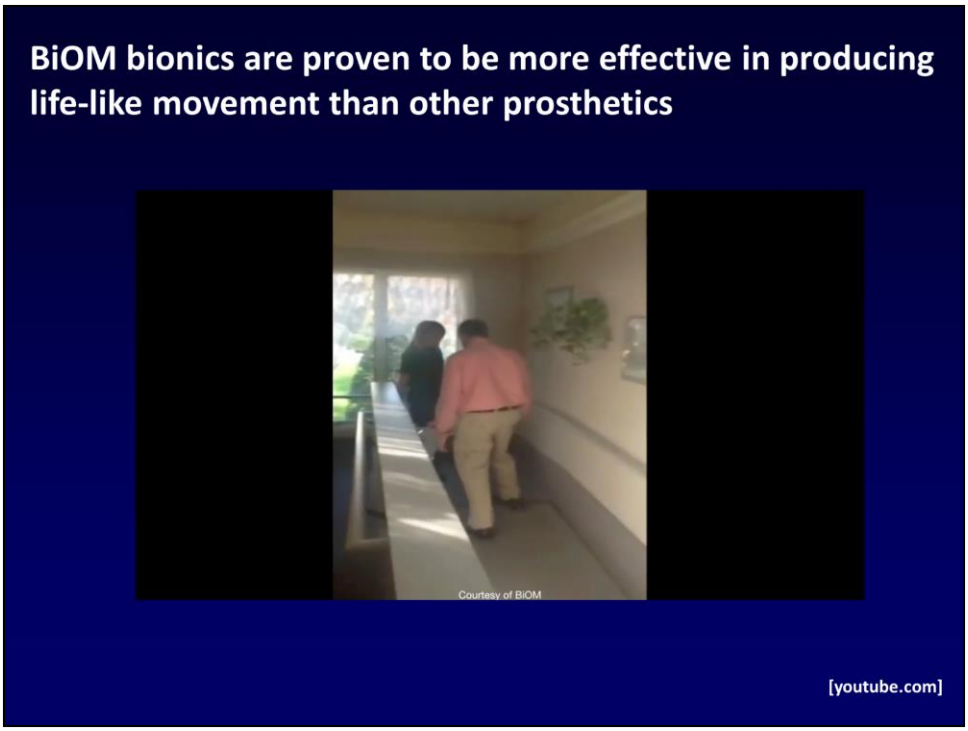
Next are electrical interfaces which cover how the bionics communicate with the nervous system. Electrodes are the main contributor to this. Electrodes measure the electrical pulse of muscles which are then communicated to the bionic limb. As you can see in the video, when he thinks about moving his phantom limb (or his real leg), the robot tracks the desires and makes it happen.

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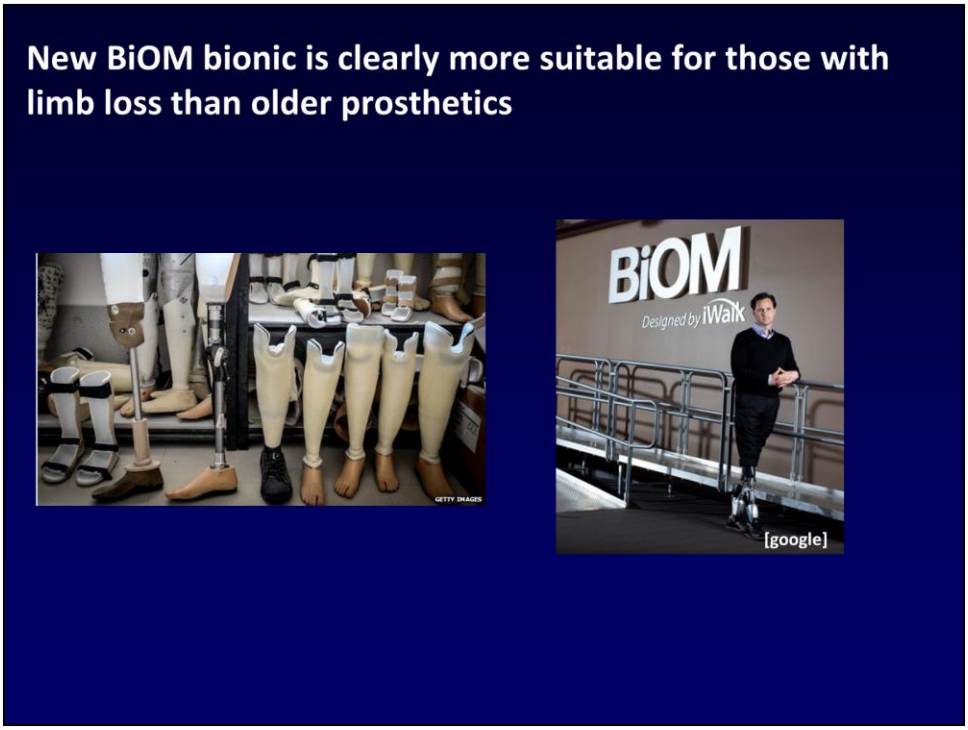
As you will see, BiOM bionics are clearly more efficient when it comes to precise control and life-like movement. In this video, you will see the dynamic interfaces at work. On the left is a woman wearing a pair of bionics that undergoes bionic propulsion. On the right, she is wearing bionics that do not undergo bionic propulsion and the difference is evident.

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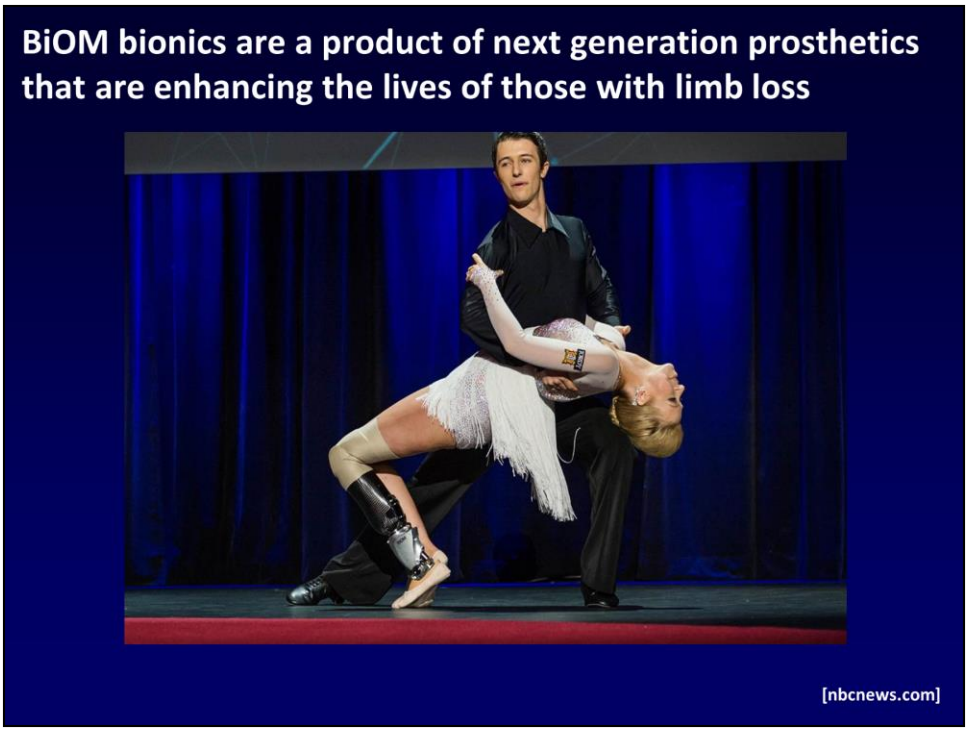
Here is a video of a woman named Lisa shortly after she was fitted with BiOM bionics. If the sound was on you would be able to hear how easy it was for her to not only walk, but also walk up the inclined ramp at the same speed she did going down. She says “It feels like a real leg. It’s pushing me right up!”

https://www.ted.com/talks/hugh_herr_the_new_bionics_that_let_us_run_climb_and_dance#t-236207



In conclusion, I first talked about the problems with limb loss as well as the technology behind traditional prosthetics. Limb loss results in a complete disconnection between the brain and the limb and traditional prosthetics cause irritation and discomfort. Next, I explained the BiOM, a new bionic that connects with the body through mechanical, dynamic, and electrical interfaces. As you saw in those videos, the technology behind the BiOM allows those who use them to have great amounts of power, control and efficiency. According to technologyreview.com, the BiOM system has undergone more than 20 iterations and has funded roughly $50 million of grants.

https://www.technologyreview.com/s/526786/bionic-ankle-emulates-nature/



The BiOM bionic system is changing the lives of those with limb loss. For these people, they are regaining all their power and ability they had previously and then some, as you saw with Hugh Herr. I would like to finish today with one last quote from Hugh Herr and if there is anything from this presentation I would want you to remember it is just this statement: “In the twilight years of the century, there will be no more disability in the world.”