In this video we take a look at origami and see how it is building the future! The paper folding art form is being used for high-tech and sci-fi-like technology developments. Everything from spacecrafts to pill-sized robots we ingest. Can origami help us find other planets that could be habitable for humans? Will origami be used to create nano-robots that are inside of us sending information to an AI doctor? And how will origami build robots that can transform and morph into different robots when needed creating a more sci-fi-like world?

Being able to fold a structure into a compact form that later expands is highly useful in space development. This is common with large solar arrays that fold out in space just like a traditional hand fan. The folding hand fan can be dated back to Japan sometime between the 6th and 9th centuries. It is one of the first functional uses of origami. Paper was originally brought to Japan by monks in the 6th century. At this time paper was expensive and folding paper was used solely for ceremonial and religious purposes. Over time as paper became cheaper origami was used more recreationally. Origami has also been discovered in a tomb in Hunan province China. It was used as the first known form of advertising packaging. It is thought to have held pigments of oil paint. The origami packaging had decorative designs along with information about the quality, the type of pigment and the address of the store that sold them. One of the first uses of origami in space was the space flyer unit launched by Japan in 1995. It was a satellite with a folded array of solar panels using the miura ori folding technique. Moving forward to 2010 the Japan Aerospace Exploration Agency launched the Icarus. This spacecraft used a solar sail that propelled it from earth to about 80 000 kilometers away from Venus. A solar sail works like a boat sail but instead of wind light particles are bouncing off of the sail in space moving it forward. The spacecraft is then able to move through space at close to the speed of light. Allowing it to travel to other solar systems possibly within a hundred years which would take tens of thousands of years with today's chemical rockets.

The planetary society run by Bill Nye has already launched and tested two generations of solar sails. LightSail 2 uses materials that are thinner than a human hair. The thin material along with origami folding methods allows for a larger solar sail to be packed and launched into space. To really see space origami in action then we need to have a look at starshade. When a space telescope wants to observe and image an exoplanet bright stars can wash out the images. The same thing happens when you're trying to look far away on a sunny day the sun's brightness can make it hard to see. This is solved by holding your hand up to block the sun. A star shade acts like your hand. It will move in between the stars and the telescope allowing faint planets to be imaged. This lets space telescopes study other planets and see if there are other earth-like habitable planets where life might be possible. These star shades would have to be large. In space the star shade would unfold to a diameter of about 85 feet. So, NASA is working on origami techniques to fold and allow them to fit into a rocket. Originally space stations were made of solid non-foldable modules. This meant that the international space station took 30 launches to build.

Bigelow Aerospace and other companies such as Sierra Nevada are working on inflatable space station modules. These modules would fold up tightly inside of a rocket then inflate in space creating large structures with fewer launches. The international space station already has one inflatable module called beam. Which was installed in 2016. t is made up of two metal bulkheads an aluminum structure and multiple layers of fabric. Future designs such as the Olympus module look to be much larger. It would require a much larger rocket such as SpaceX’s starship. But when in space it will expand to be over twice the size of the international space station. This kind of large space habitat launched on an inexpensive reusable rocket such as starship would make space hotels affordable. This technique can also be used to build large habitats on the Moon and Mars. We can start to see that there are a number of benefits when it comes to using origami to develop new tech. First manufacturing in 2d is cheaper and easier in a lot of cases. Secondly large structures can be made to fold into more compact and smaller forms. This is being combined with the development of advanced materials that are as thin as the human hair.

Another benefit of origami in high-tech development is that it can allow a structure to change shape when needed. For example, a lifting robot can change into a transportation robot. Origami structures are also able to soften the shock of an impact as energy is absorbed through the creases. This can lead to developments that help with car accidents, designing of football helmets and launching rockets into space.

When it comes to using origami to develop new tech one person to keep an eye out for is a man named Robert Lang. He is a well-known origami expert and physicist. Computational origami is a branch of computer science that began with work done by Robert Lang on origami design. It models how different materials can be folded into structures. Lang worked at NASA’s JPL and has over 50 patents on semiconductor lasers, optics and has worked on space solar arrays. He has authored over 20 books on origami which have often combined the ideas of science and engineering. You can find links to his best books in the description below.

When it comes to robotics foldable robotics is an emerging and successful field of engineering. At several universities foldable robotics is being taught as a class. Researchers at the Swiss Federal Institute of Technology have been creating origami robots which they have called robogami. The lead researcher Jamie Pike says that any 3d structure can be created from a 2d shape and this is proven mathematically. Their goal is to create robots that can morph into any shape to perform a wide range of tasks. They are inspired by the movie's transformers. These robogumi robots could fold into a large robotic arm perfect for picking up certain objects then fold into a transportation robot based on the task. This is ideal for space development as it saves on the amount of equipment needed to be launched into space. In the future we will be able to launch a few sheets of origami robots and they will transform and perform any task. Harvard university have also created foldable robots that can fold themselves and walk away. These robots are made from thin layers of laser-cut wood and laminate materials the motors are controlled by a small microcontroller.

A robotic arm developed at Seoul National University in Korea can fold and extend into a rigid structure. The origami design makes it lightweight at 30 grams and is able to withstand a compressive load of 12 kilograms. The team attached the lightweight robot arm to a drone to pick up objects.

An engineer named Sean Choi from the university of Binghamton has created a battery using origami. Instead of using expensive materials and minerals found in batteries today the origami battery is made of paper. One side of the paper is painted with a carbon-based paint and the other side is coated in a nickel-based solution. Bacteria from dirty water is then used to generate the energy for the battery to store. This method would be highly useful for anyone working in remote areas with limited resources. The batteries cost five cents to manufacture and they generate several micro volts enough to run very low powered bio sensors that could improve health care in developing countries. As smartphones become more accessible in poorer regions AI doctors such as Babylon could work with cheap paper-based batteries and biosensors. This would eliminate the need for expensive lab equipment. The biosensors take samples of saliva or blood and they would return information about what the fluid has in it. The origami batteries would let the biosensors communicate with a smartphone to pass the information over to the AI. This would mean that an AI doctor could recommend which tests to take based on a patient's symptoms and with greater accuracy than a human doctor. The test results are then delivered with a diagnosis and the AI is able to give treatment and can continue to monitor the patient and change treatment plans if needed. This would bring the quality of diagnosis in poorer countries on a level with developed countries. The concept of bio-origami engineering allows for origami shapes to be created on a cellular level. Researchers from Oxford University created 2d origami templates for cells to grow onto. These templates have creases which are designed to fold when force is applied. The cells are then grown onto these origami templates. This then causes the cells to fold where the researchers had previously put the creases. They've been able to create cubes and other shapes with this technique. In the future this technique will be able to deliver medicine inside of the body to a specific area or to deliver larger payloads such as DNA nanorobots.

Harvard's Visa Institute have been developing a self-assembling and self-destructing origami DNA nanorobot. This robot can be filled with drugs and it will self-open at a desired location. DNA origami is the use of folded DNA to create nanoscale structures. In the future this could be used to create an artificial immune system to tackle health problems that our bodies cannot currently handle. For example, these tiny robots could be in our bloodstream constantly monitoring for signs of cancer or other problems. DNA robots with DNA sensors could move around the bloodstream looking for issues. DNA computers could compute what the issues are and how best to fix them. They could then dispatch more DNA robots to fix the problem.

A team of researchers from MIT have developed an ingestible origami robot made from dried pig intestine and magnets. The pig intestines that fold up are like the skeleton and body and the magnets it holds are like the muscles and motors. Once the origami robot is swallowed the capsule dissolves the origami robot then unfolds and can remove foreign objects such as button batteries as 3500 are swallowed a year in the u.s eliminating the need for surgery. The robot can also patch wounds and deliver medicine to specific areas. Currently the robot is controlled by an external magnetic field but in the future the robot would be self-controlled.

This work has not yet been used in humans. Fluid driven artificial muscles have been created by researchers at Harvard University. The system works by having a flexible bag with an origami skeletal structure inside of it. When water or air pressure is changed inside the bag it either expands or contracts. Using this technique the researchers were able to make grabbers, fingers and arms. These artificial muscles can contract to over 90 percent of their original length and in some cases can be stronger than human muscles. These origami muscles were created using either a laser cutter to cut thin skeletal sheets or by 3d printers. Harvard's Visa Institute is currently working on creating artificial organs using origami. Origami is being used because it is easier to make a 2d structure which then gets folded into a 3d artificial organ and using origami folding techniques allows for artificial organs that are smaller in size even smaller than biological organs but they still have a large surface area within them because of all the folded sheets. So, in the future we could have small scaled origami organs inside of us. If you would like to see the extended research that was not included in this video such as retina implants and more everyday uses of origami from airbags to kayaks then head over to our patreon membership the link is in the description and on the next episode of venture city we take a look at cyberpunk in 2020 and the ways in which people are taking back technology from creating their own internet to taking apart tesla cars hit the subscribe and thumbs up button to not miss a video