# CFAST - Cystic Fibrosis Absorbent Sponge Technology

## Abstract

Our new technology, the CFAST (**C**ystic **F**ibrosis **A**bsorbent **S**ponge **T**echnology), battles Cystic Fibrosis (CF), a genetic disease afflicting 30,000 people in the United States alone. Patients with Cystic Fibrosis produce excess mucus that covers vital organs, making it both hard to breathe and process important nutrients. CFAST is a medical patch containing nanosponges. The nanosponges will enter the body through nanoneedles on the adhesive skin side of the patch. The nanosponges will travel to the vital organs and absorb the correct amount of mucus. This will leave a healthy balance lining the patient's organs. A software application on the patient's phone monitors and records the functioning of the nanosponges. This will keep the patient informed, safe, and healthy. With the CFAST you can "C the mucus fast!".

# CFAST - **C**ystic **F**ibrosis **A**bsorbent **S**ponge **T**echnology

## Present Technology

### *Nanosponges in Medicine*

Nanosponges are spherical particles that soak up harmful bacteria and venoms. Hydrogel, which is made of water and polymers, hold the nanosponges in place so that they can soak up the toxins. Nanosponges are injected into the bloodstream. A nanosponge is coated with a red blood cell membrane from the host. Nanosponges are 3,000 times smaller than a red blood cell, so one membrane can cover thousands of nanosponges. In the human body, nanosponges are carried to our liver, which is the way our body filters toxins. From there, they exit the body. Nanosponges are helpful because they are what is called "targeted" therapy. Targeted therapy is when there is something that goes directly to the area needing medication and sparing the healthy tissue from damage. With the nanosponges, you don't need the antibiotics or other medicines that affect your whole body. In medicine, using the nanosponges can help deliver medications into specific parts of the body. Targeting drug delivery resolves some of the problems of drug treatments for a very long time for medical researchers making it possible to target specific parts without the treatment spreading to and affecting the body as a whole.

### *Current CF Treatments*

There are some technologies used to treat the symptoms of Cystic Fibrosis today. One of the more recent technologies used to clear mucus is an inhaler called the FLUTTER. When using the FLUTTER, the patient inhales, and it sucks the mucus up from the back of his/her throat.

Another form of current Cystic Fibrosis treatment is oxygen therapy. A common effect of CF is breathing problems. As a result, not enough oxygen is delivered to the blood. Oxygen therapy is a way to provide patients with the ability to breathe more easily and have the needed amount of

oxygen in the bloodstream. The patient receives the treatment through a face mask that allows them to inhale oxygen. Some other ways are tubes up the nose or a tube placed up the trachea.

Current treatments help to relieve the patients of the symptoms and extend their lives. Their symptoms are decreasing allowing them to live a more normal live. With the hard work of scientists and doctors, access to treatment will widen and medicine will continue to advance. This technology will help others for years to come.

## History

Cystic Fibrosis (CF) is a genetic disorder that affects all organs in the body including the lungs, liver, and pancreas. The digestive juices in a regular person's body are normally thin and slick like oil. But in people with Cystic Fibrosis, these juices are thick and sticky causing the mucus to build up and block airways and organs. This makes it extremely hard for people with Cystic Fibrosis to breathe. However, we need mucus to survive. It lines our organs and protects them, but too much could lead to serious problems.

Cystic Fibrosis was first discovered in 1938 by Dr. Dorothy Hansine Andersen. Back then, the life expectancy for a child with Cystic Fibrosis was just one-year-old. This disease has been around a while, but research for treatments didn't start until around 1955. In 1961, two centers were made for researching and treating Cystic Fibrosis. Then, in 1962, the life expectancy raised to 10 years. According to current research of CF, in 2017, the life expectancy reached 37 years.

The Cystic Fibrosis disease is genetic; it is passed down from the parents to the child. More than 10 million people are carriers of the CF gene in the United States of America. This means they have one abnormal CFTR (Cystic Fibrosis Transmembrane Conductance Regulator) gene and one regular one. If two CF carriers have a child, there is a 25% chance that their child will have CF. A 50% chance that the child will be a carrier, but they will not have CF.

Treatments of Cystic Fibrosis have improved over the course of time. One of the treatments that people use is a High-Frequency Chest Wall Oscillation which is also called the Vest. The Vest is made up of two parts: an air pulse generator, and an inflatable vest. It is connected to the generator by hoses. The Vest inflates and deflates as much as 20 times per second. It takes mucus off the airway walls.

Another treatment is a lung transplant. Sometimes CF progresses too much that the patient needs a donor lung(s). A lung transplant can extend a life for years, and can improve well -being. It can also help the patient breathe better. However, getting a lung transplant is risky. After the lung are implanted into the patient, they need immunosuppressant drugs. This weakens the immune system, so they don't experience a rejection. A rejection is when the immune system attacks a foreign part of the body (mainly illnesses). If the immune system attacks the new lungs, it can destroy them and the person will pass away because they won't be able to breathe. Also, weakening the immune system makes the person more immune to illnesses.

A common side effect of Cystic Fibrosis is CF Related Diabetes. Thick mucus causes scarring of the pancreas. Scarring of the pancreas is when the pancreas becomes inflamed, which makes the it unable to produce the right amount of insulin.

While Cystic Fibrosis cannot be cured there are many people who are working very hard to improve the quality of life for their patients. Every day, researchers and doctors are making new strides in CF treatment and diagnosis. Hopefully, in the near future, people with CF will be able to live a long and healthier life.

## Future Technology

Cystic Fibrosis has been a life threatening problem and challenging disease to treat. CF causes a person to retain excess mucus that covers and blocks the areas of the inside of the body. It causes respiratory issues, CF related Diabetes, fatigue, and a disability to consume the needed amounts of nutrients - vitamins, calories, and fats. Over 30,000 Americans are dealing with its effects every day. While we have made much progress in diagnosing the symptoms of the disease, a new technology called The CFAST (**C**ystic **F**ibrosis **A**bsorbent **S**ponge **T**echnology) has taken this progress to a new level.

CFAST is a nanosponge made of a polymer core and a red blood cell membrane which coats each nanosponge. Nanosponges are intended to "soak up" toxins within the body. For a CF patient, this toxin is the damaging mucus. This technology will enter into the body by using either a transparent patch or, if desired, a tattoo-like patch, containing nano-sized CFAST sponges. The patch has many nano-needles that will deposit the sponges into the bloodstream. The nano sized needles make the process painless. The patch will be placed on the upper arm. The mucus adheres to the membrane and allows it to pass through to be absorbed by the sponge. This patch will have a microprocessor that is programmed to be able to detect when the new sponges need to be released into the bloodstream because mucus is present in abnormal amounts. The saturated nanosponges will filter through the liver to exit the body.

At the end of the day, an app on the patient's or their parents' cell phone will tell them how much mucus was collected that day. It stores the information in a mucus collection log. The patient can show the recorded progress to their physician by showing them the mucus collection log. If the mucus in the patient reaches a dangerously high level, the app will buzz and vibrate. It will then

immediately alert the patient's doctor. If at any point there is a malfunction with the nanosponges, the app will detect it.

Another feature if the CFAST is that the nanosponge can release antibiotics when an infection is detected. Infections are a common side effect of people who have Cystic Fibrosis. Lung infections are especially common because the mucus within the lung builds up and causes bacteria to multiply.

Biomimicry is using biology (nature) and mimicry (repetition) to improve life for our planet. The chemical structure of the CFAST nanosponges has been replicated using biomimicry. Our technology mimics red blood cells. The red blood cells provide the membrane that coats each nanosponge.

Modern science has recently made strides using nanosponges. Our new technology, the CFAST, uses nanosponges for more advanced purposes. By absorbing excess mucus surrounding vital organs, Cystic Fibrosis patients can thrive and live more comfortable lives.

## Breakthroughs

While the CFAST is a very systematic and effective product, there are still some aspects of our design that are still futuristic and prevent it from being in existence today.

One breakthrough necessary to make CFAST a reality is creating a nanosponge that can attach to just the right amount of the mucus needed to be extracted. These nanosponges can't take away all of the mucus because mucus lines and protect organs. Our technology will need a way to precisely measure the right balance of healthy mucus in the body organs.

Another obstacle of the CFAST is that different kinds of mucus line different organs. It is difficult to create a membrane coating for the nanosponges that will recognize and absorb all types

of mucus. In order for the nanosponges to be effective, the membrane coating must be programmed to recognize all types of mucus. It is not possible to complete this task because we cannot program the liquid coating. This is not achievable because a liquid has never been coded before. In order to complete this mission, we must continue to discover advancements in technology.

For the nanoneedles to continuously release sponges as needed there has to be a way for the patch to recognize when the sponges in the body is saturated. This breakthrough is important to control so the sponges work correctly so there isn't too many or too few inside the body.

Another breakthrough will be to be able to create nanoneedles at a large scale that can make up our patches in today's medicine nanoneedles are being used in injections and vaccinations. Our nanoneedles need to be allowed to pass the nanosponges through them painlessly.

Although synthetic red blood cells are being created by scientists to be delivered as drugs into the body, CFAST will need to have a constant supply of red blood cell coated nanosponges within the patch. Nano Replicators would be necessary to do this. This is still a future hope of future technology.

One breakthrough that we can test to make our technology as efficient as possible is to experiment with ways to mimic the red blood cells' membrane so the different types of mucus can pass through it. Because our technology is twenty years ahead, we predict that by then, medical researchers will be using realistic replicas of the human body to study and test illnesses and treatments for them.

We will conduct an experiment to see if the nanosponges can absorb different kinds of mucus. We will be using one of the "medical dummies". This experiment will take place in a laboratory.

1. Create different sponge red blood cell membranes with differing amounts of holes.

2. Sponges will enter the body of the "medical dummy" through the nano-needles in the CFAST patch.
3. Scientists will use a bronchoscope inside the body to see which sponges are absorbing mucus and which are not.
4. The sponges that collect the most varieties of the mucus will be selected for use in the actual product.
5. This experiment will be repeated until a membrane that will absorb all types of mucus is found.

## Design Process

There were many different ideas that we had to make life better for people who suffer with CF. Some of our ideas could someday be successes, however, we chose the CFAST because it is efficient and long-lasting.

One of our original ideas was called the Medical Mouse. The Medical Mouse is a smartwatch that connects to your body. It monitors your blood pressure, Glucose levels, cholesterol, body heat, and blood sugar. We did not choose to research this product because it was not futuristic and could be manufactured within the next 3-7 years. We already have smart devices that monitor body signs and report the results to us. The CFAST focuses on one disease and monitors the condition of the patient while treating him/her at the same time.

Another idea that we had was for the nanosponges to enter the body through a dissolvable powder. The patient would mix the powder with water and drink the beverage. He/she could choose the flavor of their powder to make it more appealing to kids. Kids are picky and this would be a way for them to have a little fun. The previously consumed liquid would not take into effect

automatically because it has to pass down through the stomach/digestive system. The CFAST technology improves upon this because the sponges enter the bloodstream directly.

The final idea we dismissed was for the nanosponges and antibiotics to enter the body through an injection. It would be a quick way for the nanosponges to enter your vital organs through your upper arm. However, over the course of the next twenty years, injections may no longer exist because of developing technology. Using nano-needles and a patch seemed to be more futuristic twenty years from now.

## Consequences

In all walks of life, new discoveries, and even old ones, have consequences. Some are convenient, however, some are problematic. Our technology, the CFAST, has many positive consequences but also some complications.

*Positive consequences of CFAST:*

- CFAST is the first technology for Cystic Fibrosis that treats the disease, rather than the symptoms of the disease.
- The fun design of a tattoo can make the CFAST more appealing to children.
- The CFAST uses nanoneedles, so the injection is pain-free.
- The CFAST treatment takes place continuously, unlike most other treatments that need to be repeatedly used.
- The CFAST works almost instantly and removes the majority of symptoms from CF within a couple of days\
- The CFAST is easy to use and can be applied by the patients with Cystic Fibrosis.
- The CFAST works with software to provide information about the patient's disease.
- The CFAST helps patients to avoid constant appointments with their physician.

*Negative Consequences of the CFAST:*

- The CFAST may put too much responsibility in the patch and takes away too much responsibility from the doctors to monitor the patient.
- The app's notification software runs on electricity and Wi-Fi. If the power went out, how will the patient know if something's wrong.

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THE CFAST
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CYSTIC
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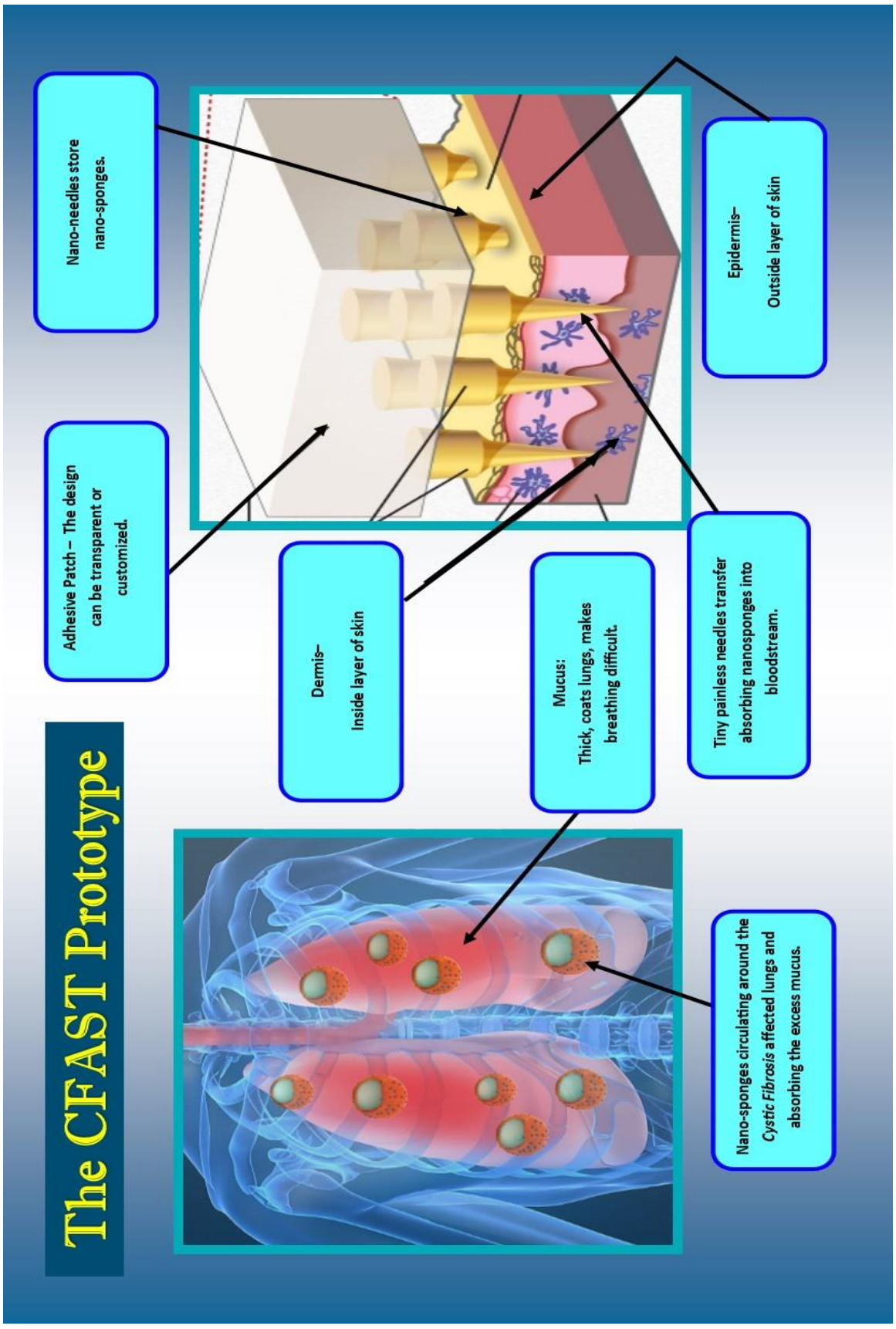
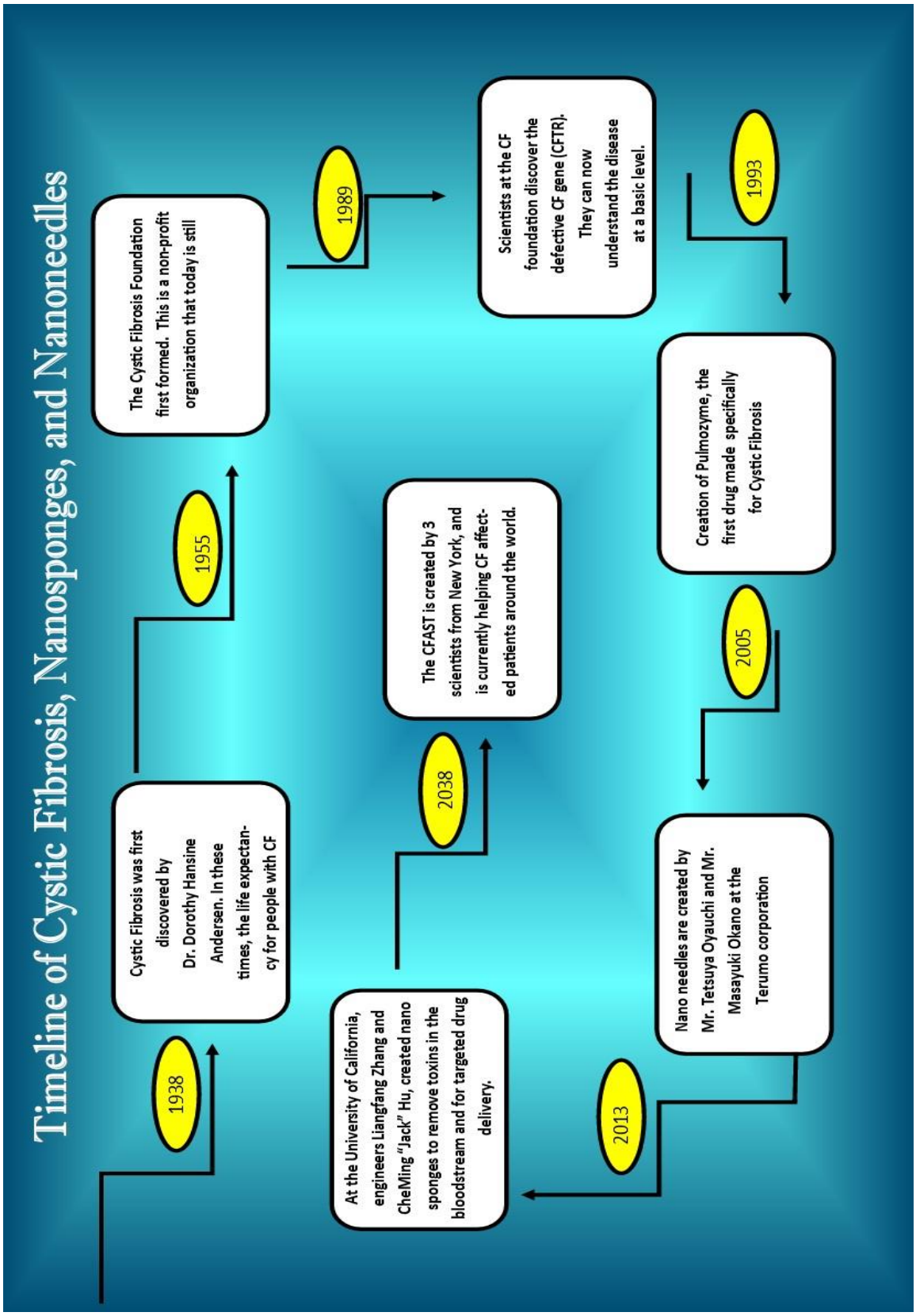
The Cystic Fibrosis Absorbent Sponge Technology
Menu
Home
Prototype
Nano Knowledge
Timeline
About the CFAST


The CFAST Prototype
Nano-needles store nano-sponges.
Adhesive Patch – The design can be transparent or customized.
Dermis–
Inside layer of skin
Mucus:
Thick, coats lungs, makes breathing difficult.
Tiny painless needles transfer absorbing nanosponges into bloodstream.
Epidermis–
Outside layer of skin
Nano-sponges circulating around the *Cystic Fibrosis* affected lungs and absorbing the excess mucus.

# Nano-Knowledge


**Nanosponges, Medical Miracles!**


Timeline of Cystic Fibrosis, Nanosponges, and Nanoneedles
1938
Cystic Fibrosis was first discovered by Dr. Dorothy Hansine Andersen. In these times, the life expectancy for people with CF
1955
The Cystic Fibrosis Foundation first formed. This is a non-profit organization that today is still
1989
Scientists at the CF foundation discover the defective CF gene (CFTR). They can now understand the disease at a basic level.
1993
Creation of Pulmozyme, the first drug made specifically for Cystic Fibrosis
2005
Nano needles are created by Mr. Tetsuya Oyauchi and Mr. Masayuki Okano at the Terumo corporation
2013
At the University of California, engineers Liangfang Zhang and CheMing "Jack" Hu, created nano sponges to remove toxins in the bloodstream and for targeted drug delivery.
2038
The CFAST is created by 3 scientists from New York, and is currently helping CF affected patients around the world.


About The CFAST: An Interview with The CFAST Creators
Why did you invent The CFAST ?
We wanted to create a technology that helps people who have Cystic Fibrosis (CF). CF is a medical disorder that causes mucus to be a lot thicker than normal, and causes trouble breathing.
How does The CFAST work?
The CFAST (Cystic Fibrosis Absorbance Sponge Technology) uses nanosponges to absorb excess mucus surrounding vital organs. The nanosponges are deposited into the bloodstream through nanoneedles in an adhesive patch on the patients arm.
What are the benefits of The CFAST?
Present day Cystic Fibrosis treatments take hours to help the patient; the nanosponges work all day long, with no help from the patient. The patch can be designed by the patient, to make it more appealing. Finally, The CFAST uses painless nanoneedles to release the nanosponges into the bloodstream.