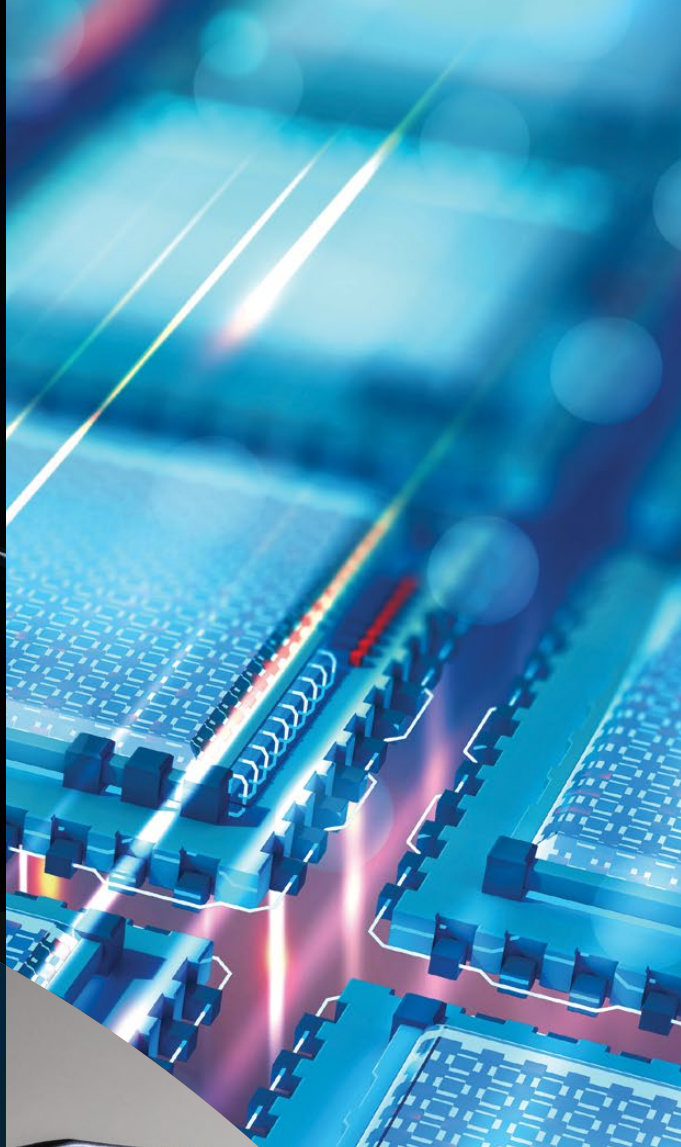
2020 Impact Report



Caltech Technology Transfer & Corporate Partnerships

COLLABORATION
INNOVATION
ENTREPRENEURSHIP

Service of Discovery

As the COVID-19 pandemic took over the world, scientists and engineers at Caltech and JPL pivoted their research to help support needs created by the spread of the novel coronavirus.

VITAL

At the beginning of the pandemic in March, it quickly became clear that there was a global shortage of traditional ventilators to treat COVID-19 patients. As a response, researchers at the Jet Propulsion Laboratory (JPL), rallied to design a high-pressure ventilator. The team focused on developing a ventilator that could be built quickly, at a low-cost, and with fewer parts by utilizing components out in the market that were easily available through existing supply chains. In an astonishing 37 days, the VITAL (Ventilator Intervention Technology Accessible Locally) prototype was created by the team at JPL. VITAL has a simple design that allows for various use-cases world-wide. By the end of April, the ventilator system was approved by the Food and Drug Administration (FDA) for emergency use. OTTCP at Caltech, which manages JPL for NASA, has provided a free license to the VITAL design to over 20 manufacturers world-wide to build the ventilator.

Wearable Temperature Sensor

As COVID-19 infection rates surged, it also became evident that a fever, or an elevated core body temperature, was a common symptom. The lab of Dr. Chiara Daraio, G. Bradford Jones Professor of Mechanical Engineering and Applied Physics, has been utilizing its understanding of how materials are structured and function to develop a thin polymer-based wearable sensor that can monitor a patient's core body temperature. The lab designed a dual heat flux calorimeter which thinly layers the temperature sensing polymer material in stacks which enables the measurement of the flux of heat from the interior of the body to the surface. This unique polymer material allows for an architecture and temperature detection sensitivity that was not possible with prior existing temperature sensing solutions. In order to fully develop a wearable temperature sensor using the material, the team is working with Dr. Azita Emami, Andrew and Peggy Cherng Professor of Electrical Engineering and Medical Engineering, to miniaturize the electronics and test the device. Ultimately, the device will permit for easy remote monitoring of patients, not only at home but also in clinical settings.

Testing Sensor through Small Amounts of Blood or Sweat

Over time, it became evident that an easy to use, rapid test to identify COVID-19 infections in people was critical to contain the spread of the pandemic. Dr. Wei Gao's, Assistant Professor of Medical Engineering, lab specializes in wireless bioelectronic devices for personalized and precision medicine for the monitoring of various conditions. Utilizing their expertise, the lab designed a sensor composed of graphene structures coupled with antibodies, proteins, and inflammation biomarkers to detect the presence and severity of the COVID-19 infection in a matter of minutes by analyzing small amounts of blood or sweat. This technology allows for the quick and easy monitoring of infection rates without the high cost of lab equipment typically associated with current testing technologies. With further large-scale testing, the lab's long-term goal is to obtain approval to make the low-cost sensor available for in-home and workplace monitoring. The novelty of this sensor technology is that it provides a platform for monitoring future types of infectious disease threats.

Vaccine Development Platform

The COVID-19 pandemic is being caused by the SARS-CoV-2 virus which falls in the coronavirus family. The lab of Dr. Pamela Bjorkman, David Baltimore Professor of Biology and Bioengineering; Executive Officer for Biology and Biological Engineering, has focused on utilizing antibodies to fight coronavirus infections. The lab has developed a vaccine platform by creating a protein-based nanoparticle composed of a multiple conjugation sites to which different coronavirus spike protein sequences can be attached. These mosaic nanoparticles serve as a vaccine with the potential to cross protect across the sarbecovirus family, providing broader protection in a single vaccine.

These few examples show the power of science to tackle one of the most challenging issues humanity is currently facing and to help preserve life.

Recent Launches

Brimstone Energy Inc.

Brimstone Energy Inc. is a clean cement company founded by Cody Finke (PhD ‘20) and Hugo Leandry (staff scientist) utilizing technology out of the lab of Dr. Michael Hoffmann, John S. and Sherry Chen Professor of Environmental Science. Concrete is the most consumed human-made material on the planet. Cement, the binder in concrete, is responsible for 5.5% of greenhouse gas emissions, the same level as from cars. Cement is thought to be particularly difficult to decarbonize because the majority of the emissions are completely unrelated to energy or fossil fuels. Brimstone aims to develop and implement a technology which will make carbon negative, fully regulated, low cost, ordinary portland cement that does not rely on extrinsic carbon capture or taxes of any kind. Brimstone has won numerous awards including Cody becoming an Activate fellow at Cyclotron Road and Hugo being honored as Forbes 30 under 30 for Energy.

Palamedrix

Palamedrix is a biotechnology company built on research performed in the lab of Dr. Paul W.K. Rothemund, Research Professor of Bioengineering, Computing and Mathematical Sciences, and Computational and Neural Systems. The company focuses on a chip-based platform that integrates molecular biosensors to enable the simultaneous and sensitive measurement of tens of thousands of protein, DNA, and RNA biomarkers to provide integrated, single cell, multiomics data enabling drug and biomarker discovery. It is currently developing Caltech inventions into an industrial process that can be executed at the world’s largest computer chip foundries.

Entos Inc.

Entos Inc. is an LA-based startup company co-founded by Dr. Thomas F. Miller III, Professor of Chemistry, who is serving as the CEO. The start-up’s breakthrough technology enables molecular modeling at ultra-highspeeds and with unprecedented accuracy, to yield thousand-fold or more increase in modeling efficiency relative to conventional molecular modeling techniques. Entos has released Qcore, Sierra, and Envision software packages for commercial licensing, leading to major contracts with industry leaders like Dow, Inc., grant funding from The Eric and Wendy Schmidt Fund, and strategic partnerships with NVIDIA.

Switch Therapeutics

Switch Therapeutics is a startup company developing a new generation of RNAi therapies based on revolutionary technology developed in the lab of Dr. William A. Goddard, Charles and Mary Ferkel Professor of Chemistry, Materials Science and Applied Physics at Caltech as well as scientists from City of Hope and Harvard Medical School. Switch Therapeutics is co-founded and led by Caltech alumni, Dr. Dee Datta as the CEO and Dr. Si-Ping Han as the CTO. The company has designed a novel class of siRNA drugs called Conditionally Activated siRNAs (CASi) that target siRNAs to specific cell types in order to address a fundamental problem in drug development: safe targeting of critical dysregulated genes that are important in normal homeostasis that cannot be safely targeted by current approaches.

Caltech Technology Transfer & Corporate Partnerships

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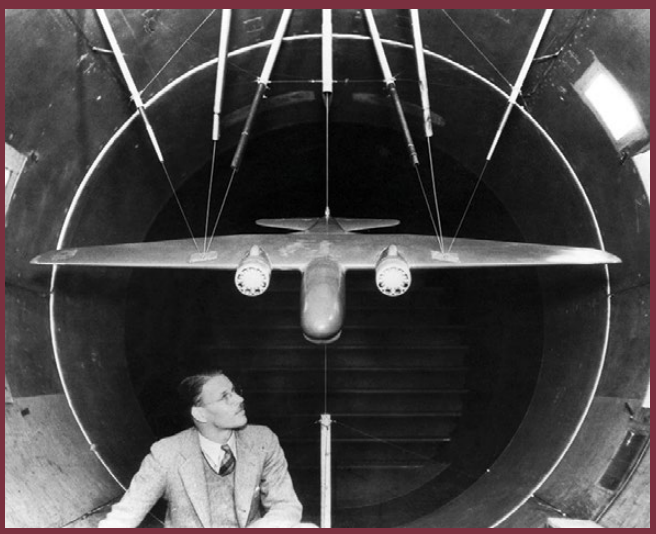
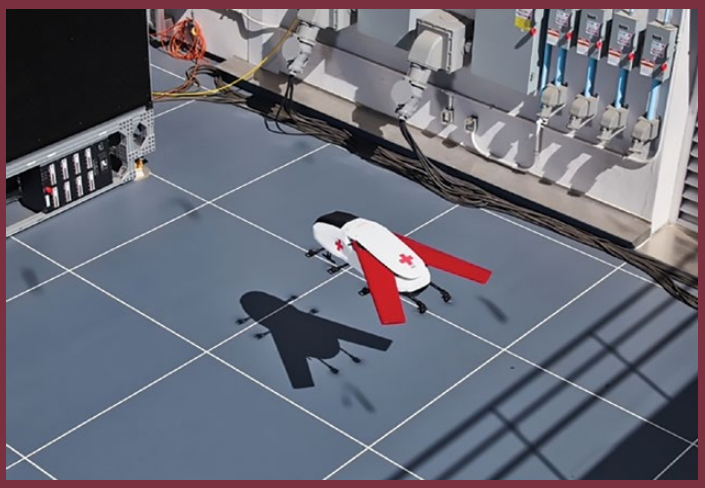
COLLABORATION INNOVATION ENTREPRENEURSHIP

History of Caltech with Aerospace

Southern California has played a major role throughout the history of aerospace in the United States and the world. This history is deeply intertwined with Caltech and the Graduate Aerospace Laboratories at Caltech (GALCIT). Companies that would go on to become giants in the field of aerospace, such as Douglas Aircraft, started as startups in the area; by 1928, over 20 aviation companies were located in Southern California, fueled by investments that came into the field as landmark achievements such as Lindbergh's transatlantic flight spurred the public's imagination of what might be possible with future innovations. Daniel Guggenheim, an avid supporter of aviation, provided the original funds for Caltech to create a laboratory and graduate program for aerospace; in 1928, Caltech opened GALCIT, including a 10-foot wind tunnel that was the heart of the facility.



GALCIT faculty, students, and facilities were key enablers of innovation for these early companies. Professor Arthur Raymond worked at Douglas Aircraft during the week and taught at Caltech on the weekends; one of his courses on airplane design was attended by Theodore Von Karman, who would go on to make seminal discoveries in aerospace. Prof. Raymond himself would go onto to serve as a VP at Douglas, and other GALCIT faculty also held dual roles in companies and at Caltech. The wind tunnel was used for aerodynamic testing by many companies; Northrop used it for the first complete scale model airplane (the Northrop Alpha) in 1930. In 1932, the Boeing Aircraft Company tested their YO-31A airplane in the tunnel. Since then, Boeing's collaborative research relationship has lasted almost 90 years. GALCIT graduates were heavily recruited by the aerospace companies and drove incredible growth throughout their operations.



GALCIT's history of innovation and close partnerships with industry continue today, and current research thrusts have a view on the future: bio-inspired engineering, the understanding of the physics of fluids and solids, space technologies, and autonomous systems and technologies. The new Center for Autonomous Systems and Technologies (CAST) houses a unique enclosed aerodrome where testing and development of drones takes place representing the next generation of user facilities that test breakthrough technology. Recent collaborations with Northrop Grumman and Raytheon Technologies, among others, have involved visiting scientists and shared facilities in ways that harken back to the founding of GALCIT, and speak to Caltech's focus on solving the most fundamental problems but also spurring their translation to the real world.

Supporting Innovation Through Corporate Collaboration

Caltech Innovation Day, held in November 2019, showcased and fostered partnerships in the biotechnology and life science industry while promoting awareness of the growing bioscience entrepreneurial ecosystem in Pasadena. Caltech industry collaborations were highlighted along with presentations by faculty on the latest scientific breakthroughs throughout the day long event. The event also provided an opportunity for leaders of the bioscience community of LA to interact and discuss the future of innovation in the field. Highlights from the day included: a keynote speech by Dr. Mory Gharib, Hans W. Liepmann Professor of Aeronautics and Bioinspired Engineering, on his entrepreneurial journey as a faculty member taking ideas from the lab to create successful startups, a panel discussion on the LA biotech ecosystem, and a talk by Peter Moglia, Co-Chief Executive Officer and Co-Chief Investment Officer of Alexandria Real Estate Equities, Inc., providing insights into how to build a greater LA life science ecosystem. Also, the Amgen Early Innovator Award was presented to Dr. Lu Wei, Assistant Professor of Chemistry, for her work in the development of novel protein free in vivo imaging methods. The event was made possible thanks to the support of Amgen, Alexandria Real Estate Equities, and Caltech's Office of Technology Transfer and Corporate Partnerships.

Caltech's Strength in Quantum Science

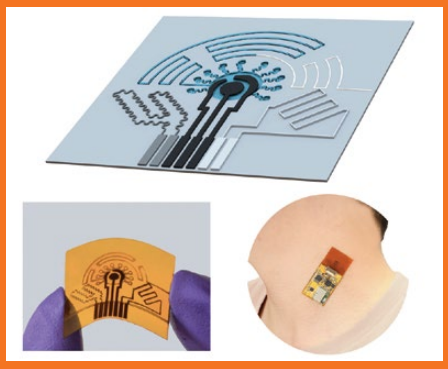
Caltech has been a home for pre-eminent quantum scientists and engineers since its founding. One of Caltech's initial flagship programs was a visiting scholars program launched in 1921 that brought quantum notables such as Paul Dirac, Erwin Schrödinger, Werner Heisenberg, Hendrik Lorentz, and Niels Bohr to campus. Albert Einstein's visits to the campus in the early 1930s cemented Caltech as a premier institute for the study of quantum physics.

Caltech's strengths in experimental and theoretical quantum science and technology extends through today, and recently Caltech has become a leading incubator in the emerging field of quantum engineering, including quantum computing. In December of 2019, Caltech and Amazon Web Services (AWS) announced a multi-faceted partnership around quantum computing that will bring together AWS scientists and engineers and academics from Caltech and beyond, working collaboratively on both the experimental hardware needed for quantum computers as well as the theoretical underpinnings to develop algorithms and error correction techniques to make quantum computers useful. Dr. Oskar Painter, John G Braun Professor of Applied Physics and Physics and Dr. Fernando Brandao, Bren Professor of Theoretical Physics, are leading the effort along with a growing number of Caltech collaborators who are working as Amazon Scholars, including John Preskill. The home of this collaboration will be the AWS Center for Quantum Computing on Caltech's campus, and the partnership also supports graduate students and postdoctoral fellows working in the quantum sciences and engineering.

Caltech's visiting scholars program brought preeminent quantum scientists to campus 100 years ago. Similarly, Caltech and AWS hope the Center for Quantum Computing will serve as a test bed for top scientific and engineering minds to address the fundamental challenges that must be overcome in order to bring the promise of quantum computing to reality.

Ideas in the Lab

Rothenberg Innovation Initiative (RI2) 2020 Awards



Laser-engraved wearable sensor by Wei Gao.

A gift from Caltech Trustee James F. Rothenberg and his wife Anne launched the Caltech Innovation Initiative (CI^2) in 2009 to provide essential seed funding for early-stage research that addresses pressing problems and could lead to marketable technologies that benefit society. Each RI^2 award provides up to two years of support, with up to $125,000 in funding per year, to help the Caltech professors, students, and post-docs mature their research beyond the conceptual stage to the point that the innovations are attractive to outside investors for further development of the technologies. Bolstered by an additional $15M gift in 2017 and renamed the Rothenberg Innovation Initiative (RI^2), the program funded seven new projects and two renewal projects in 2020.

- **LiDAR on a Chip**
  Ali Hajimiri, Bren Professor of Electrical Engineering and Medical Engineering, EAS
- **Development of a Non-Contact Image Based IOP Tonometer** (renewal)
  Morteza Gharib, Hans W. Liepmann Professor of Aeronautics and Bioinspired Engineering; Booth-Kresa Leadership Chair, Center for Autonomous Systems and Technologies; Director, Graduate Aerospace Laboratories; Director, Center for Autonomous Systems and Technologies, EAS
- **Bioinspired, self-organizing neural networks for real-time machine learning**
  Matt Thomson, Assistant Professor of Computational Biology; Investigator, Heritage Medical Research Institute, BBE
- **Smart Bandage for Online Monitoring and Treatment of Infected Chronic Wounds**
  Wei Gao, Assistant Professor of Medical Engineering, EAS
- **Wearable Opioid Monitoring System for Personalized Pharmacokinetics**
  Henry Lester, Professor of Biology, BBE
- **A novel neuropeptide-targeted drug screening platform**
  David Anderson, Seymour Benzer Professor of Biology; Tianqiao and Chrissy Chen Institute for Neuroscience Leadership Chair; Investigator, Howard Hughes Medical Institute; Director, Tianqiao and Chrissy Chen Institute for Neuroscience, BBE
- **A Dendritic Pore Blood Analysis Platform for Detection of Pathogens at Zeptomolar Concentrations** (renewal)
  Julie Kornfield, Elizabeth W. Gilloon Professor of Chemical Engineering, CCE Katherine Faber, Simon Ramo Professor of Materials Science, EAS
- **Sub-Milliwatt Analog Processor for Edge Computing and Machine Learning**
  Michael Roukes, Frank J. Roshek Professor of Physics, Applied Physics, and Bioengineering, PMA
- **Wearable Core Body Temperature Sensors**
  Chiara Daraio, G. Bradford Jones Professor of Mechanical Engineering and Applied Physics, EAS

Innovation.
Entrepreneurship.
Collaboration.

Our mission is to drive the transfer of scientific and engineering knowledge created by our researchers to maximize societal impact by developing partnerships with industry through the creation of new ventures, collaborations with corporations, and transfer of intellectual property while nurturing an entrepreneurial environment.

FY 2020

106
Invention Disclosures
(campus only)

192
U.S. Patents Issued

1,951
Active U.S. Patents

97
Licenses Granted
(including options)

12
Startup Companies

39
Companies
Sponsoring Research

72
Companies Giving Gifts

$65.75
Corporate Contracts & Gifts

Year in Review

From Fred Farina, Chief Innovation and Corporate Partnerships Officer

It's an understatement to say that 2020 was a challenging year for many in our Caltech/JPL community and for even more people around the world. This annual report, while reflecting our traditionally shared facts & figures also bears witness to this historic year and hopefully communicates some of the silver linings from what were otherwise difficult situations. They say that necessity is the mother of invention, and from OTTCP's vantage point, it was truly remarkable to see the innovation and creativity that Caltech and JPL research groups applied towards the COVID-19 pandemic. Some of the stories in this report highlight these innovations, and I'm sure we're likely to see more to come in a wide variety of areas, ranging from disease modeling to diagnostics to better therapies and vaccines.

In any historic moment, perhaps it's only natural to look back to previous points in history to make sense of the current moment or to seek guidance for what the future may hold. Coincidentally, 2020 also marked the 100th anniversary of Throop College of Technology changing its name to the California Institute of Technology, and I was struck in reading the Archives' "Becoming Caltech" feature of how much World War I had impacted the development of new disciplines and their application to existing challenges. In this annual report, we highlight how Caltech played a role in the creation of the aerospace industry in Southern California and also share a story about the new partnership between Caltech and AWS in the area of quantum computing. It will be interesting to see what historians 100 years from now say about this time in Caltech's history and I am confident that we will continue to play a role, in close collaboration with our partners, in developing wholly new fields in response to the needs of society.

I am immensely proud of all that we as a Caltech community have been able to accomplish in this very difficult year. Looking ahead to 2021, I see only additional bright spots, including the first investments from Caltech's inaugural seed fund, new modes of interactions with our corporate partners, and, more importantly, the return of the face-to-face meetings with faculty, students, and partners on our beautiful campus.

To a hopeful, bright and innovative future,

Fred Farina