

## Spring 2021 Report

This report provides an overview of accomplishments in the first year of operation, which include:

- \$1.6 million raised
- 3 initial research themes, from basic research to application
- 6 PhD researchers hired
- Berkeley, USA headquarters and Oxford, UK satellite offices established
- A new public talk series, the Topos Institute Colloquium
- 3 papers and 8 scientific talks

More detail can be found below and on our [website](#) .

Launched in October of 2019 as a nonprofit, Topos Institute is dedicated to shaping technology for public benefit by advancing the sciences of integration and connection. Topos achieves this mission by pioneering new infrastructure for society-wide communication, computation, and cognition, based on techniques from the forefront of pure mathematics. This research is conducted in an open and accessible manner, in order to facilitate the transfer of knowledge to real-world solutions, with the best interest of society as the driving force.

# The Team

After ten months of vision setting and community building, David Spivak and Brendan Fong formally incorporated Topos in October 2019. In addition to David, the founding Board of Directors comprises:

- **Ilyas Khan** (Chair), founder and CEO of Cambridge Quantum Computing and founding chair of the Stephen Hawking Foundation.
- **Ed Kmett**, Senior Researcher at Machine Intelligence Research Institute and a prominent figure in the development and deployment of Haskell.

Researchers include:

- **David Spivak** (PhD UC Berkeley), former Research Scientist at MIT, founder of data integration company Conexus AI, and co-author of three books on category theory.
- **Brendan Fong** (PhD Oxford), applied category theorist trained at MIT, UPenn, and Oxford.
- **Valeria de Paiva** (PhD Cambridge), logic and AI expert who has held senior research positions in both industry and academia.
- **Evan Patterson** (PhD Stanford), data scientist and software engineer and lead developer of the AlgebraicJulia project.
- **Tim Hosgood** (PhD Aix-Marseille), mathematician specializing in applications to quantum computing and text translation.
- **Toby Smithe** (PhD Candidate, Oxford) a neuroscientist working on mathematical foundations of cognition and consciousness.

Topos Institute has also benefited from the guidance and advice of:

- **John Baez** (PhD MIT), Professor of Mathematics at the University of California, Riverside, and world-renowned mathematical physicist and science communicator.
- **Eugenia Cheng** (PhD Cambridge), scientist-in-residence at the School of the Art Institute of Chicago and author of five popular books on mathematics including *How to Bake Pi: An Edible Exploration of the Mathematics of Mathematics*.



# Topos Institute Research



## Connected Intelligence

Intelligence is often the result of many parts working together: neurons in a brain, species in an ecosystem, people in a society. Led by David Spivak, Topos has launched a major new research initiative to provide mathematical tools for modeling, controlling, and creating intelligence that arises from interacting dynamical and decision-making systems.

This research program addresses central questions regarding connected intelligence by building on advanced mathematical techniques such as:

- Polynomial functors, to inform the design of predictable, safe programming languages and data structures
- Dialectica categories and Chu spaces, for modeling notions of agency and multi-agent systems
- Predictive processing and active inference, cutting-edge theories in mathematical neuroscience that allow insight into the nature of consciousness

This fundamental research is applied to tasks such as the creation of new languages for concurrent systems and ubiquitous computing, which is essential in deploying the society-wide computational system that begins to link our phones, computers, trains, and even our doorbells and fridges. Topos research ensures models and languages are precise, predictable, and controllable – key aspects of addressing the threat of potential errors in such systems to our social fabric and even humanity’s continued existence.

This research is supported by the United States Air Force Office of Scientific Research, the Foundational Questions Institute, and in-kind support and collaboration from the University of Oxford, the Machine Intelligence Research Institute, and Cambridge Quantum Computing.

# Topos Institute Research

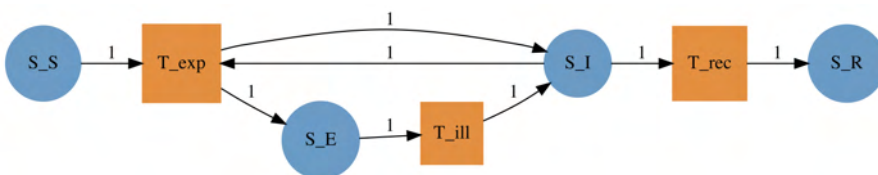
## Searchable Mathematics

Valeria de Paiva is leading a project to organize mathematics research into a searchable coherent whole, using natural language processing. Although mathematical advances are crucial to basic and applied research across numerous scientific disciplines and fields, data and findings are often sequestered and fragmented. Scientists spend 23% of their time searching literature. Topos recognizes that a new search tool will catalyze new advances across various disciplines in science, and as well as translation of research into new industrial technologies that enrich daily lives.

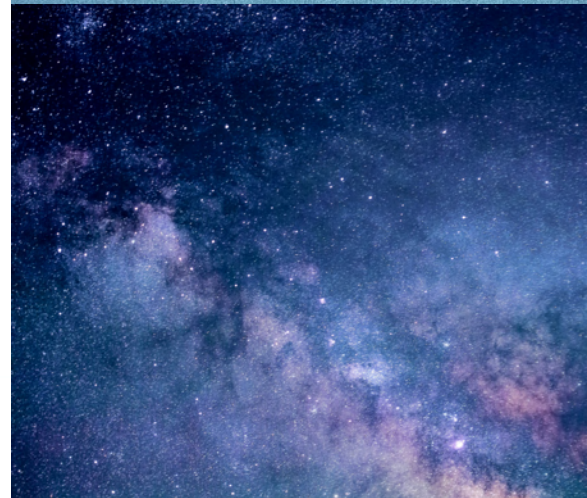
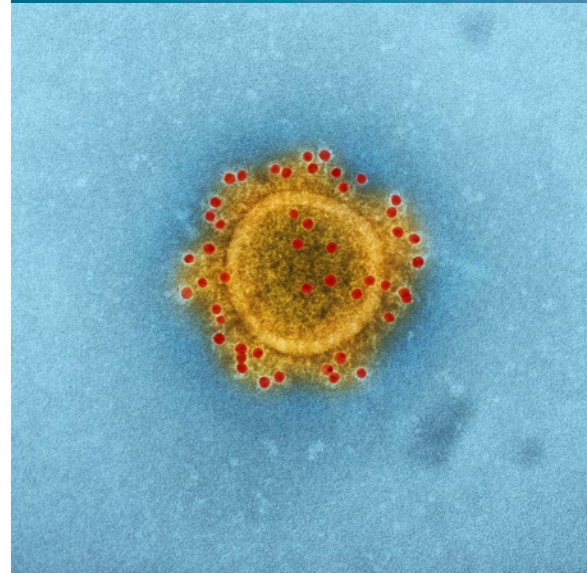
Working with collaborators at the US National Institute of Standards and Technologies, Topos is developing a pilot to demonstrate proof of principle and is aggressively seeking funding.

## Open-Source Software for Computing with Scientific Models

Led by Evan Patterson, Topos is developing open-source research software tools for computing with scientific and statistical models, to improve the productivity of researchers and reliability of scientific findings. As an example, Topos is exploring an initial application to models for COVID-19, allowing transparent yet rapid construction of models that integrate information across multiple cities and domains.



This research is funded by a contract from Georgia Institute of Technology, and conducted in collaboration with the University of Florida and University of California, Riverside.





# Community Building

## Talks and Events

The **Topos Institute Colloquium** is a weekly virtual forum for those interested in the latest research in mathematical sciences of integration and connectivity and its applications. The public seminars draw a worldwide audience on Zoom each Thursday, and recordings remain available on the Topos Institute YouTube channel. The colloquium was launched in February 2021, and has already attracted thousands of viewers.

The **Workshop on Polynomial Functors** brings together leaders in this emerging new branch of category theory to discuss the most recent research findings and applications to combinatorics, database theory, dynamical systems, higher category theory, logic, and type theory. The first edition of this workshop took place over March 15-19, 2021.

The **Emerging Researchers in Categories (Em-Cats) Virtual Seminar** is a curated series of virtual talks given by graduate students in category theory around the world, with an emphasis on creating opportunities across the diversity of the community. World-class mathematics communicator Eugenia Cheng mentors each speaker to ensure all talks are excellent.

The **Finding the Right Abstractions Summit** brings Topos researchers, leading computer scientists, and AI experts together to develop new foundational approaches for AI safety. The summit will be held virtually in May 2021. This pioneering meeting is funded by the Centre for Effective Altruism.



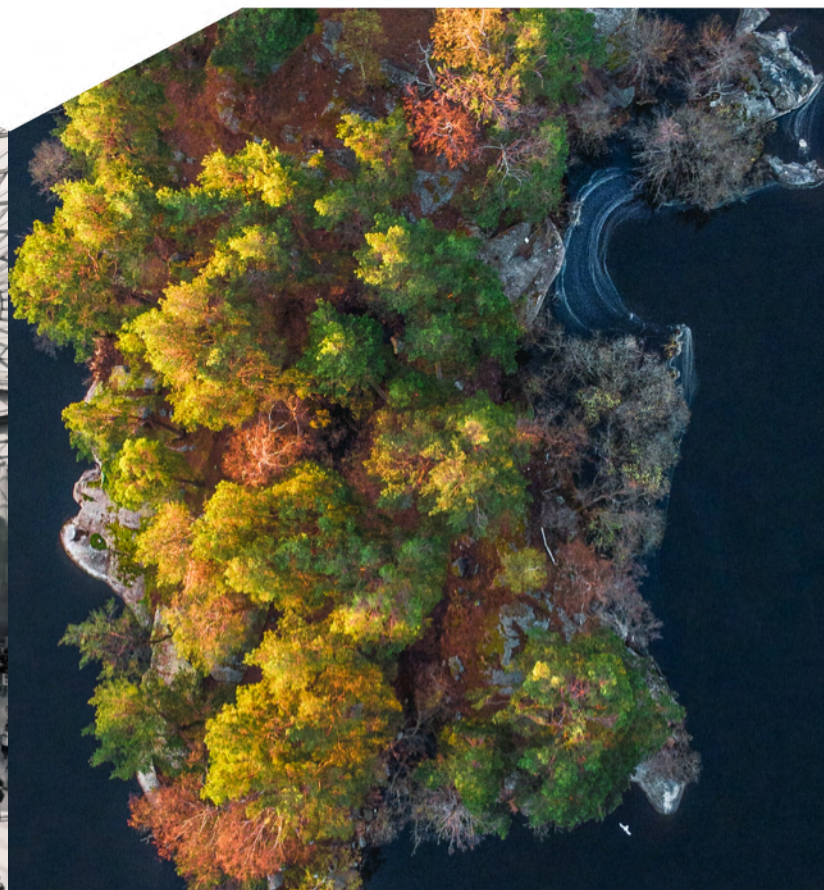
# Community Building

## Sharing Knowledge

Core to Topos Institute is the unwavering commitment that our work be shared openly for the benefit to society. In the first year, Topos staff are writing two new books, *Programming with Categories* and *Operational Semantics for Distributed Systems*, and have delivered 3 scientific papers and 8 presentations to researchers and experts nationwide and internationally.

Topos Institute and its faculty actively support a diversity of world-class initiatives to increase access to research and knowledge. A selection of examples includes:

- Administrative help for the *nLab*, the category theory community research wiki with over 14,000 pages.
- Editorial and executive leadership of open-access journals, including *Compositionality*, *Logical Methods in Computer Science*, and *Theory and Applications of Categories*.
- Leadership of the community group *Women in Logic*, which advocates for equity and inclusion in the logic research community.
- Teaching at the *Adjoint School*, an annual research school for new researchers in applied category theory with a focus on building a strong, diverse community.



# Funding

As a nonprofit organization, Topos Institute is funded through government grants, research contracts, and philanthropy. Funders include:

## Research Grants and Contracts

- US Air Force Office of Scientific Research
- Georgia Institute of Technology
- Foundational Questions Institute

## Corporate Sponsorship

- Cambridge Quantum Computing

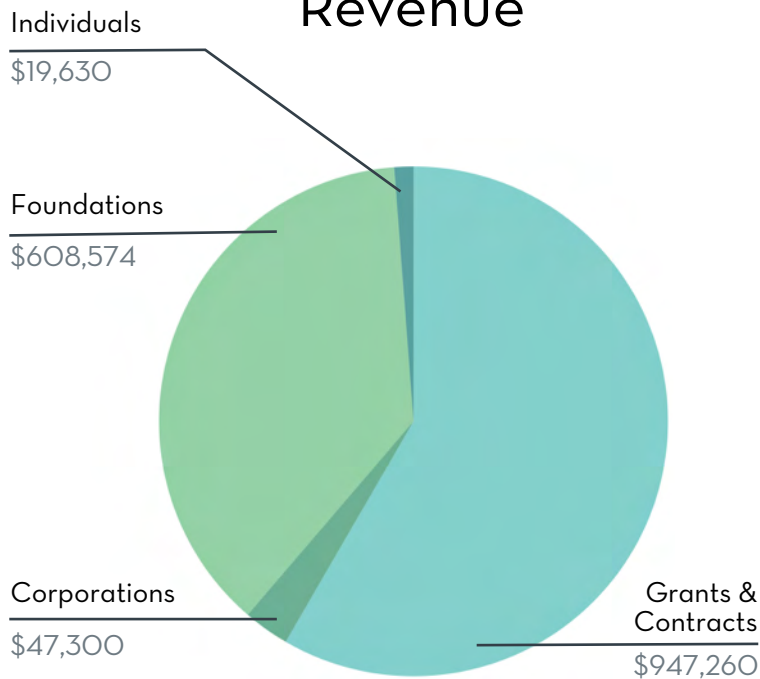
## Foundations

- Survival and Flourishing Fund/ Jaan Tallinn
- Survival and Flourishing Fund/ Jed McCaleb
- Centre for Effective Altruism/ Long Term Future Fund
- Stanhill Foundation/Ilyas Khan

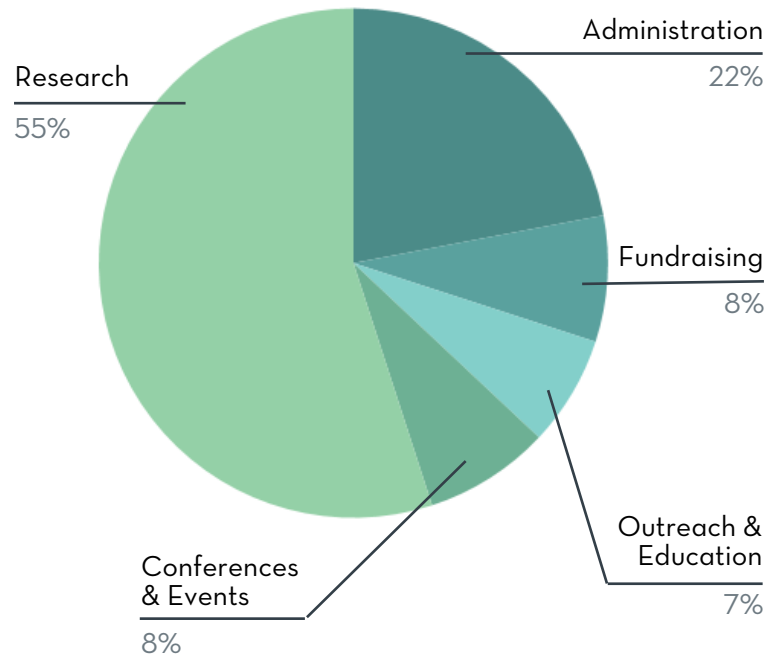
## Individuals

- Brendan Fong
- Edward Kmett
- Alan Longley
- Lee Mondshein
- David Spivak
- Tish Tanski

## Revenue



## Projected Expenses 2021



Topos Institute has an unmet need for 2021 of USD240,000. We invite those interested in pioneering a new public infrastructure of cooperation and cognition to get involved by contacting Brendan Fong, CEO ([brendan@topos.institute](mailto:brendan@topos.institute)), or by making a donation through our [website](#). Your donation will support Topos Institute, the initiatives in this report, and new directions to address challenges and embrace opportunities in our complex world.