Intelligence in the Physical World
An international request for proposals for research projects

RFP Timeline:
December 21, 2018 Intelligence in the Physical World RFP is released
February 11, 2019 Initial Proposals due
June 17, 2019 Full Proposals (invite only) due
by August 30, 2019 Grantees are publicly announced
September 1, 2019 Earliest start date for Grants
August 31, 2021 End date for all Grants
September 30, 2021 Final report on all Grants due
I. BACKGROUND ON FQXi AND FFF

The Foundational Questions Institute (FQXi) is an independent, philanthropically funded grant-awarding non-profit organization.

FQXi was launched in 2006 with the mission to “catalyze, support, and disseminate research on questions at the foundations of physics and cosmology, particularly new frontiers and innovative ideas integral to a deep understanding of reality, but unlikely to be supported by conventional funding sources.” Its goal — and success — has been to create a community of researchers, body of research, and worldwide institutional umbrella that supports daring, innovative, and deep research on scientific questions that span from the beginning of the universe to the depths of the behavior of matter to the mysteries of consciousness.

FQXi offers grants programs that serve a three-fold purpose:

· To encourage and support rigorous, innovative, and influential scientific research and collaborations on foundational questions in physics and cosmology, which may have significant and broad implications for a deep understanding of reality;

· To redress incrementalism in research programming by establishing or expanding new ‘islands’ of understanding via flexible funding of high-risk, high-reward research in these areas;

· To provide the public with a deeper understanding of known and future discoveries in these areas, and their potential implications for our worldview.

The mission of the Fetzer Franklin Fund (FFF) is to explore the frontiers of scientific knowledge and to advance breakthroughs towards scientific views of reality that are integrated and relational. In conducting its program of open exploration, the Fetzer Franklin Fund focuses on foundational questions at the frontiers of physics, biology, and consciousness research. In addition, the Fund supports work that re-examines the foundations of science, including scientific methodologies for both conventional and frontier research.

II. FOCUS ON “INTELLIGENCE IN THE PHYSICAL WORLD”

The current request for proposals targets research on Intelligence in the Physical World, both in physics and also in related fields including cosmology, astrophysics, philosophy of physics, complex systems, biophysics, neuroscience, computer science, and mathematics. Intelligence in the Physical World seeks to inspire investigations into the many connections between basic physical laws and the nature of intelligence and intelligent agents.

This program builds upon FQXi and FFF’s past program on Agency in the Physical World, with a focus on foundational questions at the frontiers of physics, biology, and consciousness research. This RFP is made as a partnership between FFF and FQXi, and administered by FQXi.

Appendix B below provides a detailed outline of the topic and questions that fall under the envisioned scope of this program.
III. EVALUATION CRITERIA & PROJECT ELIGIBILITY

In this competition, grants totaling about $1.5M will be available to researchers in academic and other non-profit institutions for projects up to two years in duration, with an end date of August 31, 2021. Grant applications will be subject to a competitive process of external and confidential expert peer review similar to that employed by all major U.S. scientific funding agencies.

Proposals will be evaluated according to their relevance and impact.

Relevance: Proposals should be topical, foundational, and unconventional.

· **Topical**: This RFP is limited to research in physics, cosmology (mainly of the early universe) and closely related fields (such as philosophy, mathematics, biophysics, complexity theory, computer science, etc.). Research should bear upon the theme **Intelligence in the Physical World**, as described more fully in Appendix B. Appropriate research topics in this category will address questions such as:

  - How are the world and its laws constituted so as to make intelligence and intelligent agents possible?
  - How are intelligent agents able to create consonance with the laws and structure of physics so as to operate effectively?
  - What are the ultimate limits of the capabilities of intelligent agents as dictated by fundamental physics?

A detailed, more specific list is given in Appendix B. It is important to note the “foundational” and “unconventional” criteria below, and that this program is unlikely to fund projects that are purely neuroscience or purely machine learning or purely theoretical computer science, etc., as opposed to projects connecting those fields to physics or another discipline in a central way that makes the project suitable to this RFP and the spirit of FQXi rather than a conventional funding source.

· **Foundational**: This RFP is limited to research with potentially significant and broad implications for our understanding of the deep or “ultimate” nature of reality.

· **Unconventional**: This RFP is intended to fill a gap, not a shortfall, in conventional funding. We wish to enable research that, because of its speculative, non-mainstream, or high-risk nature, would otherwise go unperformed due to lack of available monies. Thus, although there will be inevitable overlaps, an otherwise scientifically rigorous proposal that is a good candidate for this program will generally not be a good candidate for funding by the NSF, DOE, etc. – and vice versa.

Impact: Proposals will be rated according to their expected scientific impact per dollar, taking all relevant factors into account, such as:

· Intrinsic intellectual merit, scientific rigor and originality
· Potential for significant contribution to basic science relevant to the topic and a high product of likelihood for success and importance if successful (i.e., high-risk research can be supported as long as the potential payoff is also very high)
· The likelihood of the research opening fruitful new lines of scientific inquiry
RFP on Intelligence in the Physical World

- The feasibility of the research in the given time frame
- The qualifications of the Principal Investigator and team with respect to the proposed topic
- The part a grant may play in career development
- Cost effectiveness: Tight budgeting is encouraged in order to maximize the research impact of the project as a whole, with emphasis on scientific return per dollar rather than per proposal
- Potential to impact the greater scientific community as well as the general public via effective outreach and dissemination of the research results

Because of the unconventional nature of the FQXi and FFF missions, we encourage part-time work (15% to 40%), in parallel with the scientist's usual research, rather than full-time appointments or studentships. Acceptable uses of grant funds include:

- Student or postdoctoral salary and benefits for part of the academic year. (Applicants will be required to list the sources of other funding, secured or proposed, needed for these positions. This information will be requested for those who are invited to submit a full proposal.)
- Summer salary and teaching buyout for academics
- Support for specific projects during sabbaticals
- Assistance in writing or publishing books (please see FAQ)
- Modest allowance for justifiable lab equipment, computers, publication charges, and other supplies
- Modest travel allowance
- Experimental equipment (Keep in mind that while FQXi and FFF are very interested in experimental proposals, the total available funding means that funding for large equipment purchases will be unlikely.)
- Development of large workshops, conferences, or lecture series for professionals (Note that small programs of this type, and others costing less than US $15K, are best supported by an FQXi Mini-Grant. Mini-Grant applications, however, are restricted to FQXi Members.)
- Development of outreach or educational programs for laypeople that disseminate knowledge regarding foundational questions in physics and cosmology (The impact criterion, in this case, will be judged primarily on the proposal's ability to disseminate knowledge rather than primarily on the development of knowledge.)
- Overhead of at most 15%

To aid prospective applicants in determining whether a project is appropriate for this program, we have provided topics that make suitable targets for research funded under this program, in Appendix B. Applicants can also review projects supported in FQXi - FFF’s last RFP on Agency in the Physical World at https://fqxi.org/grants/large/awardees/list/2018.

IV. APPLICATION PROCESS

Applications will be accepted electronically through a standard form on the website, www.fqxi.org, and evaluated in a two-part process, as follows:

**Initial Proposal – DUE February 11, 2019** – Must include:

- A 300 - 500 word summary of the project, explicitly addressing why it is topical, foundational and unconventional
- A draft budget with description not exceeding 200 words, including an approximate total cost over the life of the award and explanation of how funds would be spent
RFP on Intelligence in the Physical World

- A Curriculum Vitae for each Principal Investigator, which MUST be in PDF format, each including:
  - Education and employment history
  - A list of up to five previous publications relevant to the proposed research and five additional representative publications
  - Full publication list

A review panel assembled by FQXi will screen each Initial Proposal according to the criteria in Section III. Based on their assessment, the applicant may be invited to submit a Full Proposal, around March 2019, perhaps with feedback on improving the proposal. Please keep in mind that however positive FQXi or FFF personnel may be about a proposal at any stage, it may still be turned down for funding after full peer review.

**Full Proposal** (invite only) – **DUE June 17, 2019** – Must include:

- Contact info for the person administering your grant (e.g., your institute’s grant specialist or department head)
- A 200 word project abstract, suitable for publication in an academic journal
- A project summary not exceeding 200 words, explaining the work and its significance to laypeople
- A detailed description of the proposed activities, not to exceed 15 single-spaced 11-point pages, including a short statement of how the application fits into the applicant’s present research program, and a description of how the results might be communicated to the wider scientific community and general public
- A detailed budget over the life of the award. Budget must include justification and utilization distribution (drafted by or reviewed by the applicant’s institution’s grant officer or equivalent). Please make sure your budget includes administrative overhead if needed by your institute (15% is the maximum allowable overhead)
- A list, for all project senior personnel, of all present and pending financial support, including project name, funding source, dates, amount, and status (current or pending)
- Names of 3 recommended referees
- Curriculum Vitae for all project senior personnel, including:
  - Education and employment history
  - A list of up to five previous publications relevant to the proposed research, and five additional representative publications
  - Full publication list
- **For past FQXi awardees only:** a 250-word statement explaining what was done with previous funding and how that ties in to the current proposal (if at all)

Completed Full Proposals will undergo a competitive process of external and confidential expert peer review, evaluated according to the criteria described in Section III. A review panel of scientists in the relevant fields will be convened to produce a final rank ordering of the proposals, which will determine the grant winners, and make budgetary adjustments if necessary. Public award announcements will be made on or about August 30, 2019.

**V. FUNDING PROCESS**
FQXi will direct these grants through a Donor Advised Fund (DAF) at the Silicon Valley Community Foundation. FQXi will solicit and review grant applications, and on the basis of these reviews, FQXi will advise the DAF on what grants to make. After grants have been made by the DAF, FQXi will work with the DAF to monitor the grantee’s performance via grant reports. In this way, researchers will continue to interact with FQXi, while the DAF interacts mostly with the researchers’ institutes’ administrative or grants management offices.

APPENDIX A. FREQUENTLY ASKED QUESTIONS

Do FQXi and FFF have a preferred philosophical or scientific agenda?
No. We are equally interested in all proposals with great promise and talent falling within the program purview and the parameters of the request for proposals.

Who is eligible for grants?
Researchers and outreach specialists working in academic and other non-profit institutions are eligible. Grants cannot be given to for-profit organizations or institutes. Grant awards are sent to the PI’s institute and the institute’s administration is responsible for disbursing the awards to the PI. When submitting your application, please make sure to list the appropriate grant administrator that we should contact at your institute.

Applicants need not be FQXi Members.

Can researchers from outside the U.S. apply?
Yes, applications will be welcomed from any country.

Please note that the US Government imposes restrictions on the types of organizations to which US nonprofits (such as FQXi) can give grants. Given this, if you are awarded a grant, your institution must a) prove their equivalency to a non-profit institution by providing the institute’s establishing law or charter, list of key staff and board members, and a signed affidavit for public universities and, b) comply with the U.S. Patriot Act. Please note that this is included to provide information about the equivalency determination process that will take place if you are awarded a grant. More detail about international grant compliance is available on our website at www.fqxi.org/misc/international_grants.

Can I submit an application in a language other than English?
All proposals must be in English. Since our grant program has an international focus, we will not penalize applications by people who do not speak English as their first language. We will encourage the review panel to be accommodating of language differences when reviewing applications. All applications must be coherent.

How and when do we apply?
Apply online at www.fqxi.org. Initial Proposals must be submitted by February 8, 2019. After screening, you may then be invited to submit a Full Proposal, due June 17, 2019. Please see Section IV for more information.

Do FQXi or FFF provide grant extensions?
Please note that FQXi has been accommodating with grant extensions in the past, but for this grant program we are not able to do so beyond August 31, 2021. Please ensure that you can complete the
research or outreach project you plan to apply for with a guaranteed final date of August 31, 2021 or earlier. We will require all unused grant funds to be returned after this date.

What kinds of programs and requests are eligible for funding?
- Student or postdoctoral salary and benefits for part of the academic year (Be prepared to list the source of the remainder of funding for these positions)
- Summer salary and teaching buyout for academics
- Support for specific projects during sabbaticals
- Assistance in writing or publishing books (please see additional detail below)
- Modest allowance for computer equipment, publication charges, or supplies, provided that these items are clearly justified in the proposal
- Experimental equipment (Keep in mind that while we are very interested in experimental proposals, the total available funding means that funding for large equipment purchases will be unlikely.)
- Modest travel allowance
- Development of large workshops, conferences, or lecture series (Note that small programs of this type, and others costing less than US $15K, are best supported by an FQXi Mini-Grant. Mini-Grant applications, however, are restricted to FQXi Members.)
- Development of outreach or educational programs for laypeople that disseminate knowledge regarding foundational questions in physics and cosmology (The impact criterion, in this case, will be judged on the proposal's ability to disseminate knowledge rather than develop it.)
- Overhead of at most 15%

What is your policy on overheads?
The highest allowed overhead rate is 15%. This is FQXi policy and not negotiable.

Can I request an advance for a book?
We do permit funding for book-related projects, but grants should not be viewed as a substitute for a publisher’s advance. Review panels will give preference to projects in which the writing is a part of the PI’s regular research (e.g. technical manuscripts, teaching materials), or the final product is available as a public resource, or in which the grant enables the writing but does not bear full support. In particular, we would not likely support the commission of a book that then goes to market commercially. FQXi Members should strongly consider using the Mini-Grant program for smaller book projects, in lieu of a Large Grant.

How will proposals be judged?
After screening of the Initial Proposal, applicants may be asked to submit a Full Proposal. All Full Proposals will undergo a competitive process of external and confidential expert peer review. An expert panel will evaluate and rank the reviews according to the criteria described in Section III.

Can you give me any guidance on my research proposal, and on whether or not our project fits within the funding vision?
Please see Appendix B below for example topics that appropriate research proposals will tackle. We may provide feedback on Initial Proposals invited for a Full Proposal, and also limited advice during the preparation of the Full Proposal. Please keep in mind that however positive FQXi or FFF personnel may be about a proposal at any stage, it may still be turned down for funding after peer review.

Can I submit multiple proposals?
We will consider multiple Initial Proposals from the same PI; however, we will invite at most one Full Proposal from each PI or closely associated group of applicants.

**What if I am unable to submit my application electronically?**
Only applications submitted through the form on our website are accepted. If you encounter problems, please contact mail@fqxi.org.

**Is there a maximum amount of money for which we can apply?**
No. You may apply for as much money as you think is necessary to achieve your goals. However, you should carefully justify your proposed expenditure. Keep in mind that projects will be assessed on potential impact per dollar requested; an inappropriately high budget may harm the proposal’s prospects, effectively pricing it out of the market. Referees are authorized to suggest budget adjustments.

**What will an average award be?**
We expect that research awards will average around $100,000 total over the life of the award (one to two years maximum), with outreach awards substantially smaller.

**What are the reporting requirements?**
Grantees will be asked to submit a progress report (only applicable for two-year grantees) and/or a final report consisting of narrative and financial reports. Renewal of two-year grants will be contingent on satisfactory demonstration in the progress reports that the supported research is progressing appropriately, and continues to be consistent with the spirit of the original proposal.

**What are the qualifications for a Principal Investigator?**
Since this is a program run by researchers for researchers, we may be a bit more flexible than traditional funding agencies in the definition of a Principal Investigator; thus, we may accept applications from postdoctoral fellows as the PI or a co-investigator if his/her institution allows this. Should a postdoctoral fellow be invited to submit a Full Proposal, we might request that the fellow obtain co-signatures on the proposal from the department head or a department host with a post extending the duration of the grant.

**My colleague(s) and I would like to apply as co-PIs. Can we do this?**
Yes. For administrative purposes, however, please select a primary contact for the life of the award. The primary contact, the Principal Investigator, will be the reference for your application(s) and all future correspondence, documents, etc.

**Can you fund PhD student research assistantships?**
Yes. However, because of the unconventional nature of the FQXi and FFF missions, full-time student support is discouraged. Potential students cannot directly apply for a studentship.

**Will the grants pay for laboratory expenses?**
Yes, however due to budgetary limitations we cannot fund capital-intensive equipment. Also, laboratory expenses must be clearly required by the proposed research, which must clearly fulfill the ‘foundational’ relevance criterion.

**I have a proposal for my usual, relatively mainstream research program that I may be able to neatly repackage as an appropriate proposal for FQXi. Sound OK?**
We are very sensitive to the problem of "fishing for money"—that is, the re-casting of an existing research program to make it appear to fit the overall thematic nature of this Request For Proposals. Such proposals will not be funded, nor renewed if funded initially.

**What are FQXi “Mini-Grants”?**
FQXi has initiated an on-going program to fund small projects (approximately US$1-$15K) by FQXi Members only. See www.fqxi.org/grants/mini/intro for details.
APPENDIX B: THEME AND EXAMPLE QUESTIONS

This appendix gives background information about the program theme and a grid of example questions, any of which could form the basis of a suitable proposal.

The theme for this RFP is **Intelligence in the Physical World**. It is intended as a companion to our previous program on Agency in the Physical World. The program will support investigations into the many connections between basic physical laws and the capabilities of intelligent agents.

**Agents** in the physical sense are systems capable of causing physical changes aligned with goals, reasons, drives, or needs. A basic question is, how do agents do what they do? We identify seven capabilities linked to intelligence: (1) **Remembering** by acquiring and storing information in internal states; (2) **Computing** to process the remembered information (3) **Learning** patterns and correlations in and between the external and internal world; (4) **Predicting** the evolution of systems under different assumptions; (5) **Optimizing** by comparing potential actions against goals, reasons, drives, or needs; (6) **Acting** upon the world so as to increase the probability of desired results, and (7) **Experiencing** subjectively some or all of the preceding processes.

Of each capability, we propose three questions. How are the world and its laws constituted so as to **make it possible**? How are agents able to create consonance with the laws and structure of physics so as to **make it effective**? And, what are the **ultimate limits** of it as dictated by fundamental physics?

The table below gives examples for each combination of capability and question.

<table>
<thead>
<tr>
<th>Capability</th>
<th>What makes it possible?</th>
<th>What makes it effective?</th>
<th>What are the limits?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remembering</td>
<td>Why does our universe admit a local description including relatively isolated stable subsystems? Could it have been otherwise and if so, which physical laws make the difference?</td>
<td>How isolated can a system be while remaining useful as a memory device? What are efficient error-correcting methods in a noisy environment?</td>
<td>How much information can possibly be stored in a given spatial or spacetime region? What is the thermodynamic cost of information acquisition or bit erasure?</td>
</tr>
<tr>
<td>Computing</td>
<td>What is the smallest change to our physical laws that would destroy their ability to support universal computation?</td>
<td>If the physical world allows classical and quantum computation, are there other interesting types that are allowed? Do any “natural” quantum computers exist?</td>
<td>What is the thermodynamic cost of computing? How fully can these be circumvented using reversible and quantum computation?</td>
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<tr>
<td>Learning</td>
<td>What properties of our universe enable small subsystems of it to effectively model the world around them?</td>
<td>Are learning systems maximally effective “on the edge of chaos”? Is this generally true of intelligent systems?</td>
<td>Is there a thermodynamic cost to learning? How close are living systems to paying just this price?</td>
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<tr>
<td>Predicting</td>
<td>Why are there stable mathematical physical laws? Why can they be constituted as initial-value problems? How and why can we often ignore fine-grained details?</td>
<td>What systems in general admit coarse-grained and collective variables that can be effectively predicted?</td>
<td>What is the thermodynamic cost of prediction? Are there fundamental limits to agent effectiveness based on fundamental indeterminism in physics?</td>
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<tr>
<td>Optimizing</td>
<td>How can intelligent systems infer “rules” governing a system they interact with that are different from its fundamental rules yet useful?</td>
<td>What shortcuts do humans or other biologically-evolved systems use to come to quick “intuitive” answers to problems with a huge search space?</td>
<td>What problems of practical importance cannot be short-cut? Does physical law prevent efficient solution to NP-hard problems? Why?</td>
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<tr>
<td>Acting</td>
<td>If physics is deterministic, how can meaningful action/decisions occur? What accounts for the role of “free choice” in quantum theory and foundations?</td>
<td>How can tiny causes (e.g. in brain cells) have huge “desired” effects without being drowned in chaotic amplification of many other small effects?</td>
<td>How much control can an agent in principle have to create desired effects without “side effects?” What are the ultimate bounds on what can be accomplished by an intelligent agent limited only by the laws of physics?</td>
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<tr>
<td>Experiencing</td>
<td>Do the laws of physics guarantee that any system exhibiting general intelligence is also conscious in the sense of having subjective experience?</td>
<td>Can subjective awareness be measured or probed via information-theoretic tools? Can consciousness theories be experimentally tested, and if so, can we rule out any currently popular theories?</td>
<td>Is consciousness necessarily unified or could it “pay attention” to many things at once? Is the amount of information apprehended by consciousness small by necessity, or unbounded, or something in-between?</td>
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