Request for Information (RFI)
DARPA-SN-17-13
Molecular Code and Compute

Responses Accepted: Until 4:00 PM (Eastern) on January 4, 2017
Point of Contact: DSO Solicitations, DARPA-SN-17-13@darpa.mil

The Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO) is requesting information on research related to molecular-scale information storage and computation.

As the amount of data generated worldwide continues to grow at an incredible pace and our need for ever-faster, more capable computation becomes essential, it is clear that fundamentally new approaches are required for ultradense, ultrafast information storage and computation. Recent demonstrations using DNA sequences to store digital data, coupled with several decades of work in DNA computing, illustrate that sequence-controlled polymers may be one viable path to move beyond traditional silicon-based computational architectures. Such methods exploit the inherent high information storage density at the molecular level, demonstrated at ~2.2 petabytes/g for DNA, and promise superior stability to current storage media.[1] And, while DNA has not yet demonstrated fundamentally new capabilities to rival traditional computers, the DNA computing community has laid the groundwork for digital and analog molecular-scale computing. The prospect for massively parallel computation at the molecular scale is clear.

One critical parameter in the success of DNA-based information systems is an ability to control sequence. But encoding information via sequence is not fundamentally limited to nucleic acid-based polymers, as demonstrated through significant recent progress in the field of non-natural sequence-controlled polymers. While DNA has clear strengths to meet our near-term data storage needs, non-natural systems offer inherent advantages that may ultimately be required for versatile computation, such as fast, scalable encode/decode strategies, tunable parameters (e.g., composition, stability, reactivity and light/thermal response), and diverse monomers and polymeric structures that can be optimized for desired computational function.

Accordingly, DARPA is interested in exploring ideas and research that directly couples information storage and computation using non-natural, sequence-controlled polymers in a generalizable, adaptable format that may lead to fundamentally new computational architectures in the future. To realize this longer-term goal, we must first carefully lay the groundwork and develop strategies for flexible, adaptable molecular-scale information storage (code) framed in the context of our anticipated/desired computing needs (compute).

DARPA is interested in responses in two areas:

(1) strategies for the rapid synthesis and sequencing (read/write) of polymers for ultradense information storage that can carry out computational operations, and
(2) theoretical foundations and/or computing applications that may benefit from the flexibility and highly parallel nature of such chemical systems (e.g., data-intensive

[1] Goldman, N.; Bertone, P.; Chen, S.; Dessimoz, C.; LeProust, E.; Sipos, B.; Birney, E. *Nature Lett.* **2013**, *494*, 77-80.

functions, digital and analog capability, probabilistic computation, etc.).

Responses may target one or both areas, and should be framed in the context of the ultimate goal, with careful consideration of practical factors such as the physical instantiation of (1) so that elements such as storage capacity, random access, error tolerance, resilience and encode/decode speed are addressed and will ultimately enable implementation in (2).

Approaches that rely solely on natural sequence-controlled polymers, as well as those that mimic current silicon-based computational systems, are not of interest. However, responses may include hybrid natural/non-natural approaches, and may consider compatibility with current computational architectures for early demonstrations. Responses that provide evidence or projection for performance beyond DNA-based storage and computation, or discuss the shortfalls of those approaches with respect to their ideas are encouraged. Responses that explicitly consider how molecular-level information encoding can address aspects of information assurance such as data integrity and non-repudiation are also encouraged. It should be noted again that DARPA anticipates these strategies to lay the groundwork for, not be the ultimate implementation of, a new form of computing that can collectively address our future data storage and computational needs.

Given the multidisciplinary challenge presented here, DARPA expects responses from a diverse community including disciplines such as synthetic organic chemistry, polymer chemistry, computer science, information science and mathematics. While respondents may address one or both areas in a single submission, DARPA anticipates that thorough responses addressing only one area will be informed by cross-disciplinary conversations, at a minimum. Given that groups responding to one category will not have insights into approaches/ideas submitted to the other, all responses should clearly state any assumptions, as well as any limitations in the approaches, and include any open questions that will need to be addressed to prove out the ideas.

SUBMISSION FORMAT

Respondents to this RFI are encouraged to be as succinct as possible, while also providing actionable insight. Page limits for each section are indicated below. Format specifications for responses include 12-point font, single-spaced, single-sided, 8.5 by 11-inch paper, with 1-inch margins in MS Word or Adobe PDF format. Respondents are responsible for clearly identifying proprietary information. Responses containing proprietary information must have each page containing such information clearly marked with a label such as “Proprietary” or “Company Proprietary.” DO NOT INCLUDE ANY CLASSIFIED INFORMATION IN THE RFI RESPONSE.

A. Cover Sheet (1 page): Provide the following information.
   1. Response Title
   2. Technical point of contact name, organization, telephone number, and email address
   3. Indicate the RFI area(s) addressed by the response

B. Technical Description (4 pages for responses addressing a single area; 6 pages for responses addressing both areas)

C. Bibliography/References (1 page)

SUBMISSION INSTRUCTIONS
All responses to this RFI must be emailed to DARPA-SN-17-13@darpa.mil. Responses will be accepted any time from the publication of this RFI until 4:00 PM (Eastern) on January 4, 2017. Early responses are encouraged.

CONTACT INFORMATION
All technical and administrative correspondence and questions regarding this RFI should be emailed to "DSO Solicitations" at DARPA-SN-17-13@darpa.mil.

ELIGIBILITY
DARPA invites responses from all those engaged in related research activities and appreciates responses from all capable and qualified sources including, but not limited to, universities, university-affiliated research centers (UARCs), Federally-Funded Research and Development Centers (FFRDCs), private or public companies and Government research laboratories.

DISCLAIMERS AND IMPORTANT NOTES
- This is an RFI issued solely for information and new program planning purposes; it does not constitute a formal solicitation for proposals. In accordance with FAR 15.201(e), responses to this RFI are not offers and cannot be accepted by the Government as such.
- Responses do not bind DARPA to any further actions related to this topic including requesting follow-on proposals from respondents to this RFI.
- Submission is voluntary and is not required to propose to a subsequent Broad Agency Announcement (BAA) (if any) or other research solicitation (if any) on this topic.
- DARPA will not provide reimbursement for costs incurred in responding to this RFI.
- Respondents are advised that DARPA is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI.
- DARPA will disclose submission contents only for the purpose of review. Submissions may be reviewed by the Government (DARPA and partners); Federally Funded Research and Development Centers (FFRDCs); and Scientific, Engineering and Technical Assistance (SETA) support contractors.