A Vision for NSF Earth Sciences 2020-2030: Earth in Time

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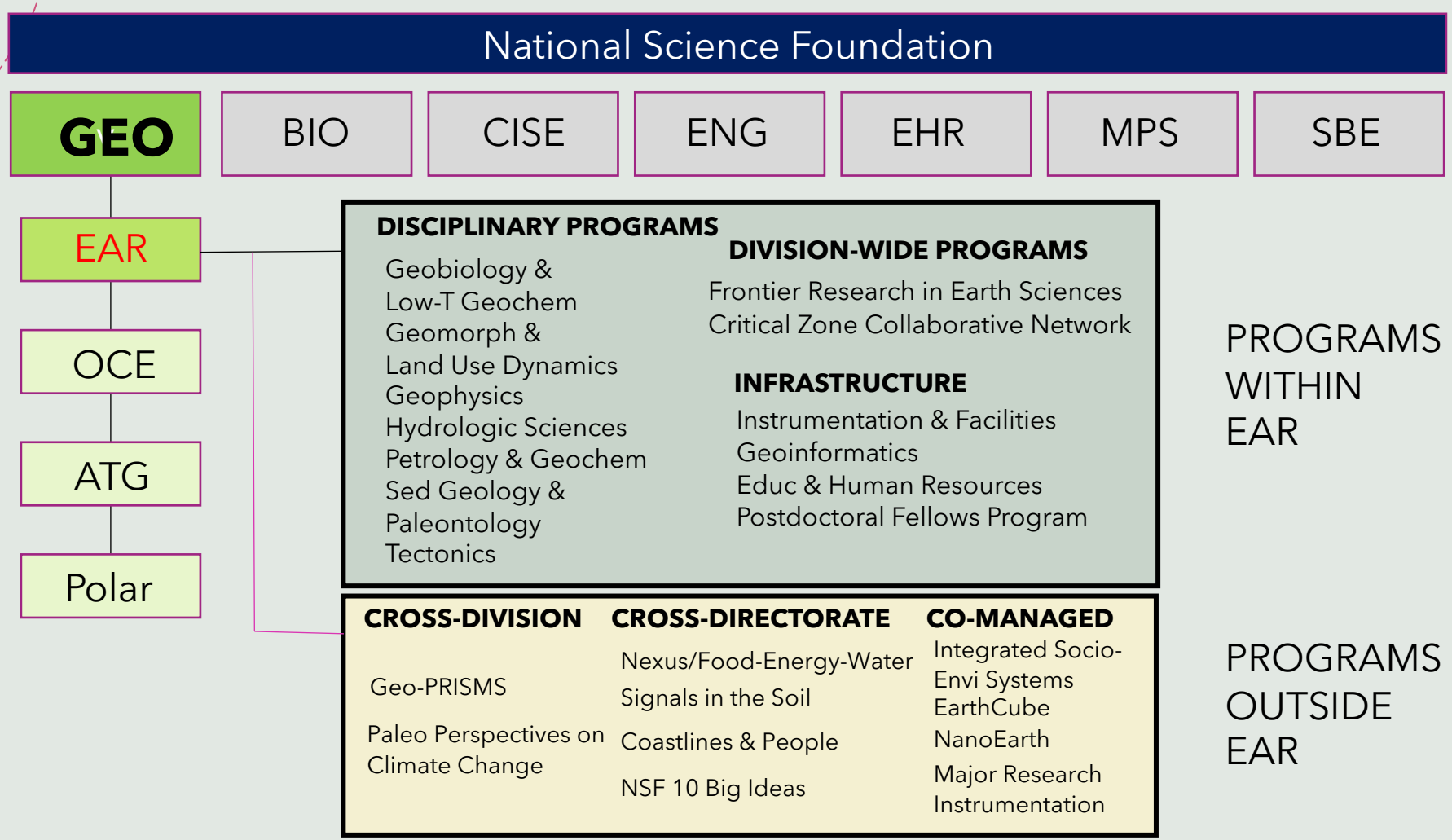
On behalf of the *Committee on Catalyzing Opportunities for Research in Earth Sciences* (CORES)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Major Research Instrumentation
PROGRAMS WITHIN EAR
PROGRAMS OUTSIDE EAR

Statement of Task

… provide advice that EAR can use to set priorities and strategies for its investments on research, infrastructure, and training in the coming decade. The report will include:

1: a concise set of **high-priority scientific questions** that will be central to the advancement of Earth sciences over the coming decade and could help to transform our scientific understanding of the Earth.

2: (A) **identification of the infrastructure needed** to advance the high-priority Earth-science research questions from task #1, (B) **discussion of the current inventory** of research infrastructure supported by EAR and other relevant areas of NSF, and (C) **analysis of capability gaps** that would need to be addressed in order to align B with A.

3: a discussion of how EAR can **leverage and complement the capabilities, expertise, and strategic plans of its partners** (including other NSF units, federal agencies, domestic and international partners), encourage greater collaboration, and maximize shared use of research assets and data

Committee roster

Jim Yoder (Chair), Woods Hole Oceanographic Institution

Greg Beroza, Stanford University

Tanja Bosak, Massachusetts Institute of Technology

Bill Dietrich, University of California, Berkeley

Tim Dixon, University of South Florida

Andrea Dutton, University of Wisconsin–Madison

Diana Elder, Northern Arizona University *(resigned)*

Lejo Flores, Boise State University

Michael Foote, University of Chicago

Shemin Ge, University of Colorado Boulder

George Gehrels, University of Arizona

Doug Hollett, Melroy-Hollett Technology Partners

Bruce Houghton, University of Hawaii at Manoa

Kate Huntington, University of Washington

Steve Jacobsen, Northwestern University

Dennis Kent, Rutgers University

Carolina Lithgow-Bertelloni, University of California, Los Angeles

Paul Olsen, Columbia University

Don Sparks, University of Delaware

Donna Whitney, University of Minnesota

with guidance from **Deborah Glickson**
National Academies of Sciences, Engineering & Medicine

vision / summary

EAR can enhance support for research on the Earth as an integrated system

This is an "**all hands on deck**" moment; we need:

- diverse, inclusive groups
- individuals, teams, and collaborative networks
- cutting-edge analytical, field, computational methods + supporting infrastructure

cover photo of the report
(Pioneer Mts, Idaho)

Science priority questions: process

Information-gathering

- literature review (white papers, review articles)
  + attempt to understand communities that don't have such documents
- community input questionnaire
- listening sessions/town halls @ conferences
- reports from community workshops
- interviews with colleagues
- invited discussions during CORES committee meetings

For all the details: search online for "CORES COMMITTEE NASEM"

Developed priorities

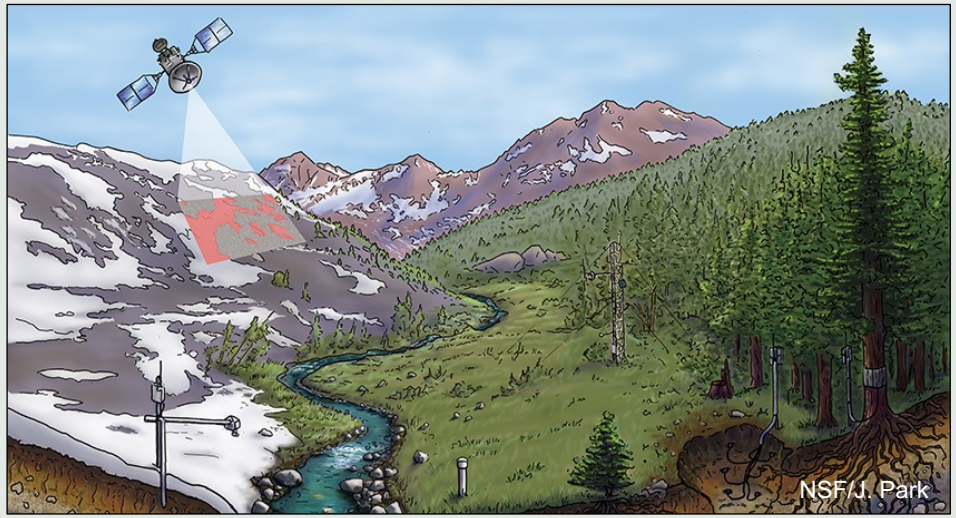
- generated a "long list" of questions
- merged similar questions / examined themes that emerged
- evaluated significance and timeliness
- framed the questions

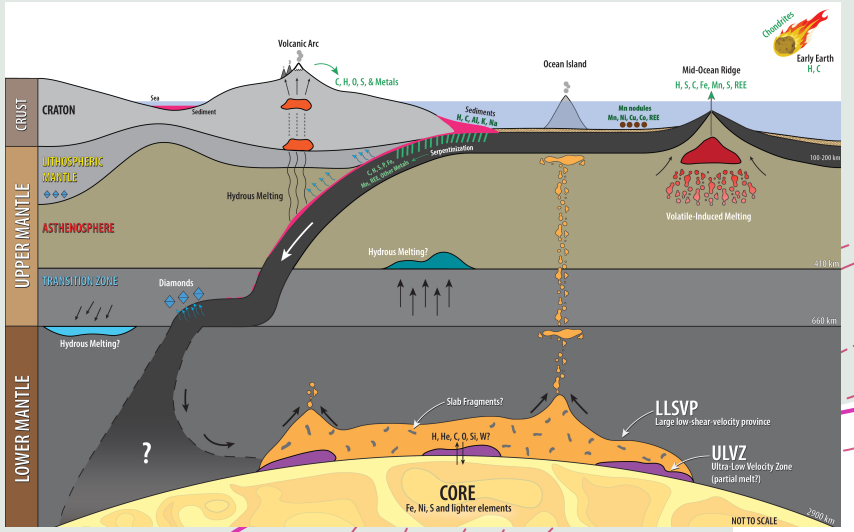
→ identified 12 questions that are **poised for major advances** in next 10 years

Some of the questions have long been of great interest.

Integrative Themes of the Science Priority Questions

- Earth system components interact over time and space
- technological advances enable new observations and modeling
- fundamental Earth science research has societal relevance
- *There will be unanticipated discoveries.*





The 12 science questions, from the core to the clouds...

How is Earth's internal magnetic field generated?

When, why, and how did plate tectonics start?

How are critical elements distributed and cycled in the Earth?

What is an earthquake?

What drives volcanism?

What are the causes and consequences of topographic change?

How does the critical zone influence climate?

What does Earth's past reveal about the dynamics of the climate system?

How is Earth's water cycle changing?

How do biogeochemical cycles evolve?

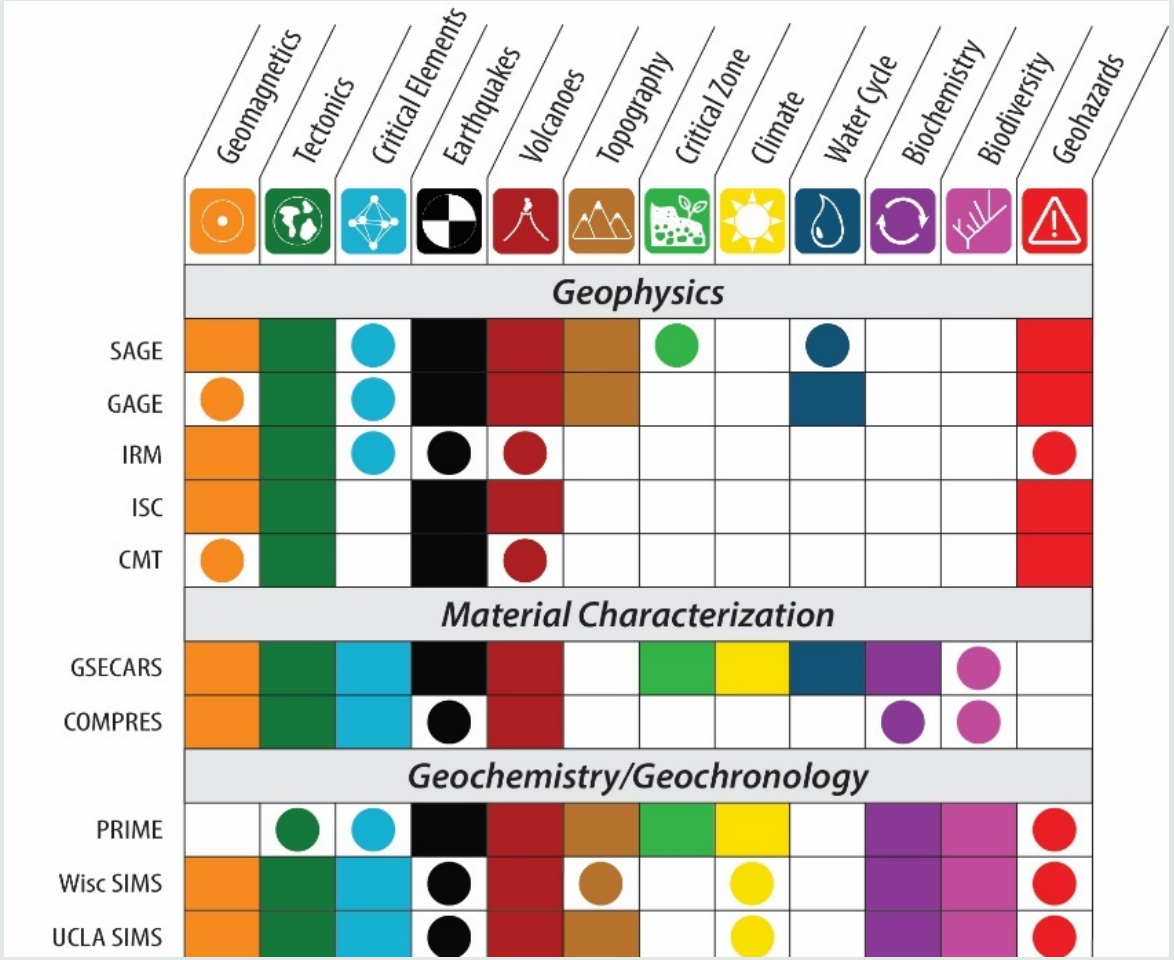
How do geological processes influence biodiversity?

How can Earth science research reduce the risk and toll of geohazards?

facilities and infrastructure: approach

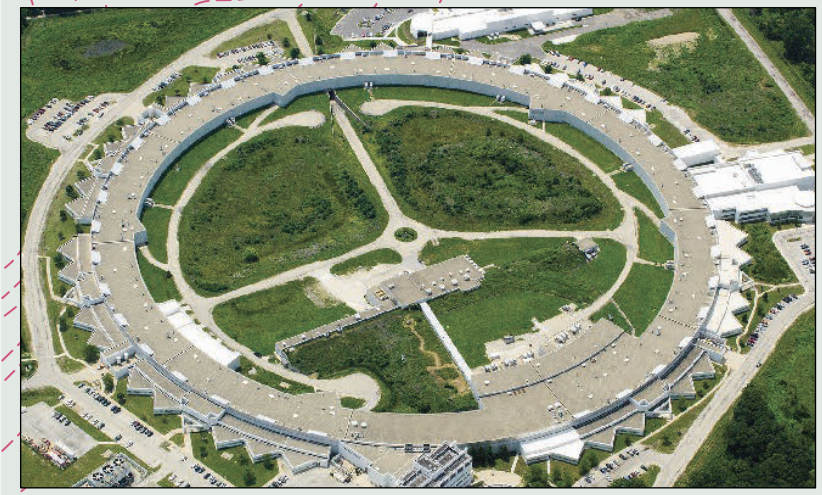
science questions

existing facilities



portion of a table from the report, showing connections between current facilities and science questions

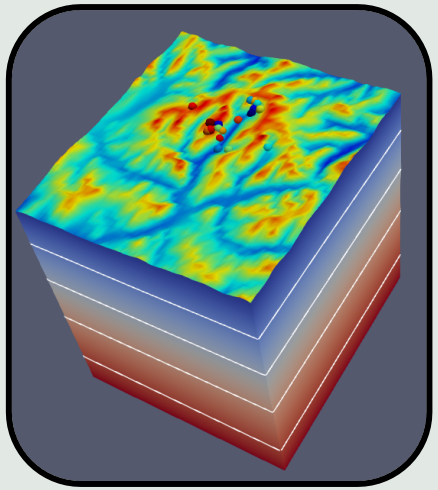
facilities and infrastructure: approach

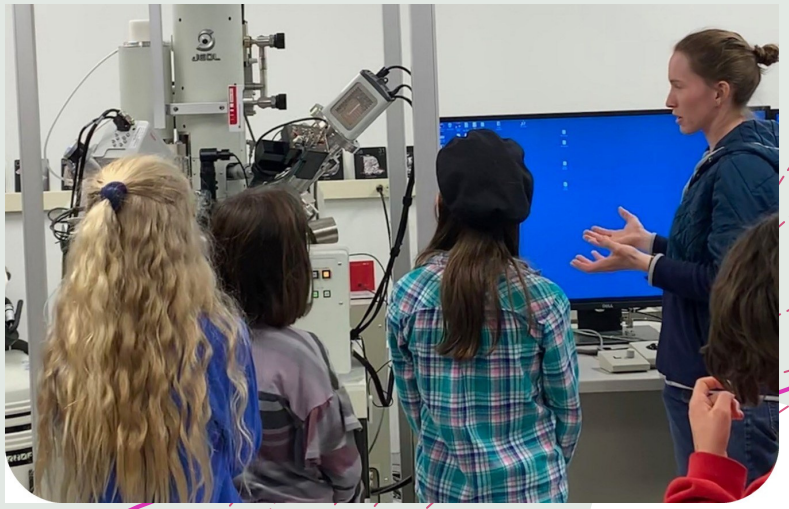


We analyzed three components of infrastructure:

- instruments
- cyberinfrastructure
- humans

(NSF 10 Big Ideas)





facilities recommendations

EAR should fund:

- a National Consortium for Geochronology
- a Very Large Multi-Anvil Press User Facility
- a Near-Surface Geophysics Center

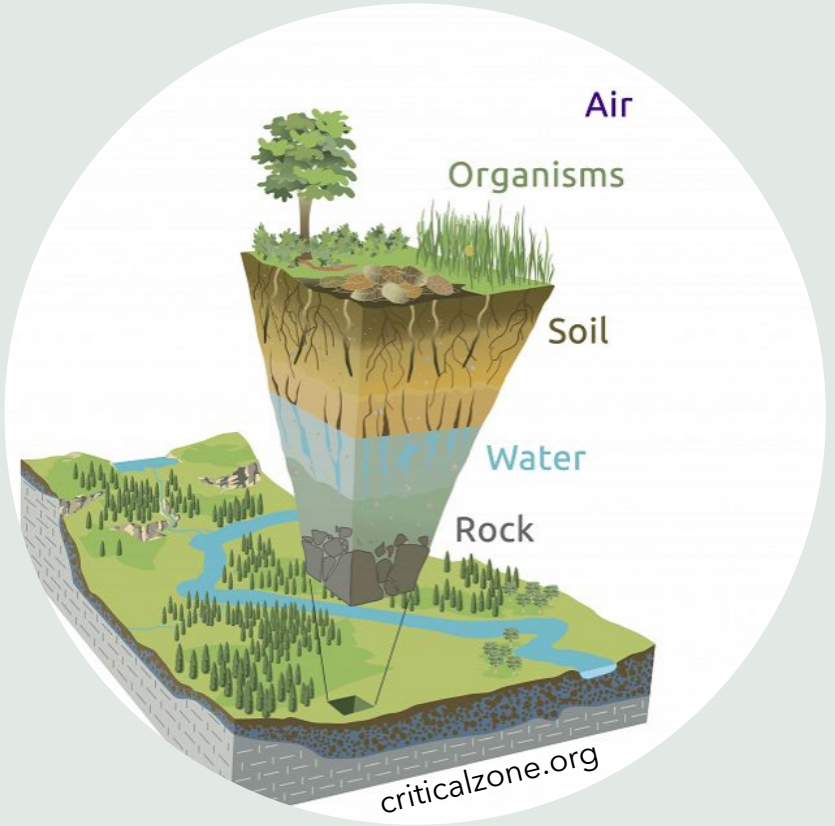
EAR should support continued community development of the SZ4D initiative, including the Community Network for Volcanic Eruption Response.

facilities recommendations

+ EAR should <u>encourage the community to explore:</u>

  - a Continental Critical Zone initiative
  - a Continental Scientific Drilling initiative

+ EAR should <u>facilitate a community working group</u> to develop mechanisms for **archiving and curation of currently existing and future physical samples** and for funding such efforts.



cyberinfrastructure recommendations

+ initiate a community-based standing committee to advise EAR regarding cyberinfrastructure needs and advances.

+ develop and implement a strategy to provide support for FAIR* practices within community-based data efforts.

FAIR = **F**indability, **A**ccessibility, **I**nteroperability, and **R**euse

human infrastructure recommendations

EAR should commit to long-term funding that develops and sustains technical staff capacity, stability, and competitiveness.

EAR should enhance its existing efforts to provide leadership, investment, and centralized guidance to improve diversity, equity, and inclusion within the Earth-science community.

partnerships: recommendations

+ EAR should collaborate with other GEO divisions and other agencies to fund geoscience research that crosses boundaries, such as shorelines, high latitudes, and the atmosphere–land interface.

+ EAR should proactively partner with other NSF divisions and other federal agencies to advance novel, societally-relevant research.

+ because Earth science is increasingly global, EAR-funded researchers benefit from international collaboration

some final thoughts

EAR's mission is more important and urgent than ever

EAR already leads investigation of Earth as an interconnected system and is poised to launch the next decade of innovative research

EAR basic research is critical to the missions of other federal agencies

Partnerships with other agencies maximize complementary work and promote high-impact science

Earth-science research and education are highly relevant to the nation and have direct benefits to health, prosperity, and security

excerpts from the concluding chapter of the Earth in Time report

(emphasis added for this presentation)

Future advances in diversity and inclusion have the potential to transform what we study—and how we do it—by unlocking new perspectives and creating new ways of framing research questions, such as by **building opportunities for citizen science and making information more accessible to decision makers and the public.**

The committee envisions a bright future, where students and scientists in academia, industry, government, and nongovernmental organizations more accurately reflect the demographics of the United States, with improved gender equality, increased participation by underrepresented minorities, and higher representation across the full spectrum of personal, cultural, and socioeconomic statuses and identities that make up our vibrant society.

… **Earth scientists will be able to more deeply engage with affected communities** to solve issues of critical societal importance, such as communicating seismic hazard along the West Coast or mitigating sea-level rise for Gulf Coast communities.

The field of Earth sciences will benefit from increasingly diverse perspectives just as substantially as it will from advances in computational geoscience and higher-precision instruments.

Thank you for listening to this presentation!

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EARTH IN TIME