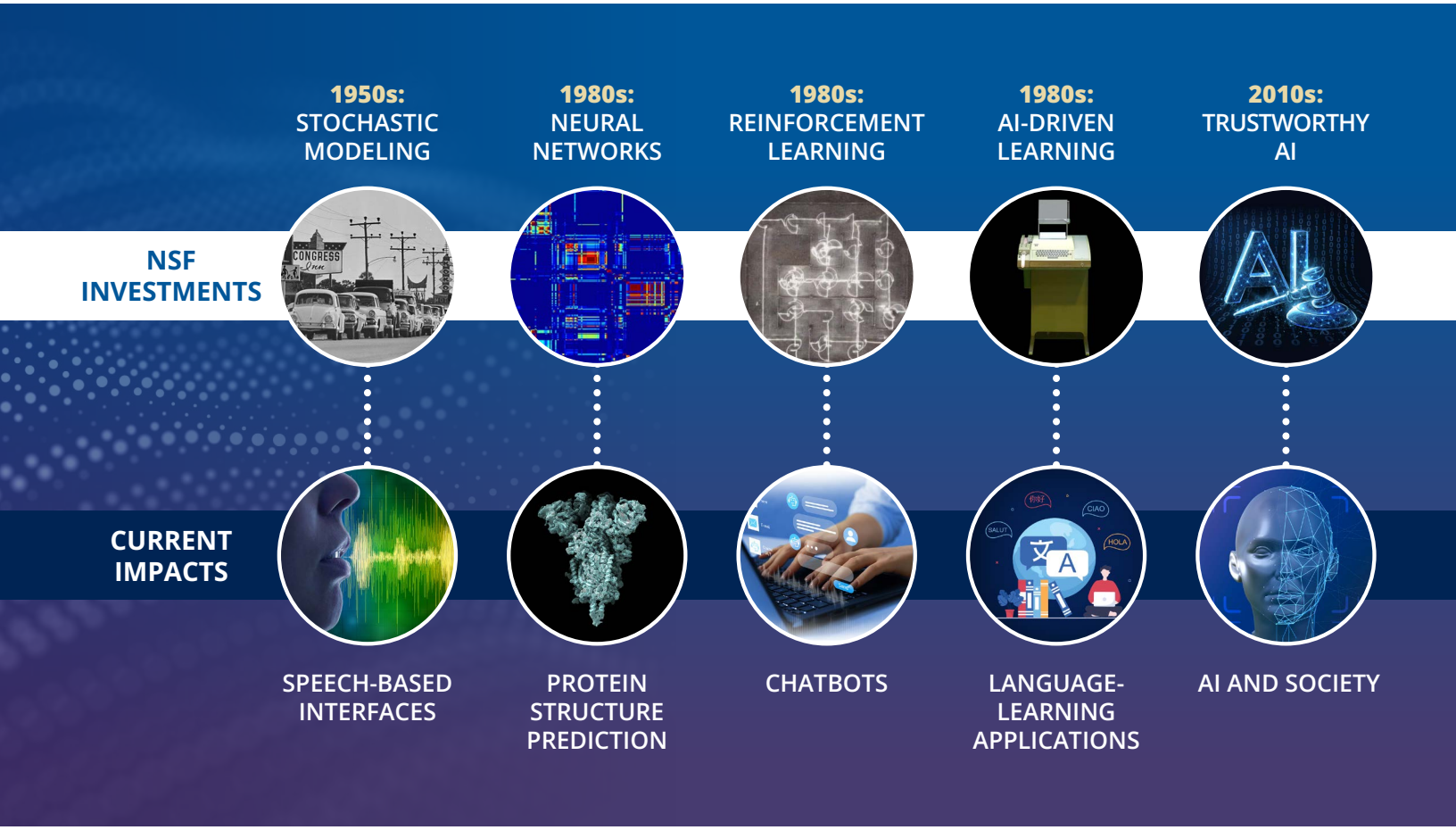
IMPACTS FROM INVESTMENTS
ARTIFICIAL INTELLIGENCE

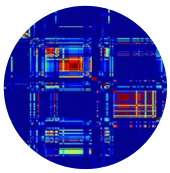
U.S. National Science Foundation

For decades, the U.S. National Science Foundation's investments in artificial intelligence have led to discoveries and innovations that are making tangible and lasting impacts on the lives of millions of people. These discoveries are helping to transform the future capabilities in human-computer interaction, education, science, problem-solving and industries such as computing and health care.



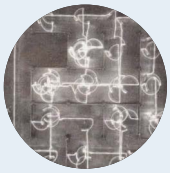
Where we benefit today: SPEECH-BASED INTERFACES
NSF investment: STOCHASTIC MODELING

Every day, drivers worldwide rely on traffic modeling in their GPS systems to guide them to the fastest routes. Similarly, internet users are routed around areas of server congestion, keeping the internet humming along smoothly for everyone. The technology powering both systems is stochastic modeling, the mathematical understanding of random phenomena. Stochastic modeling was initially developed during the 1930s and 1940s to understand phenomena such as bacterial population growth or the movement of gas molecules. In the 1970s and 1980s, NSF-funded researchers, such as Monroe Donsker, Srinivasa Varadhan and Daniel Stroock, paved the way for powerful and flexible models that predict how and when resources like these are used. Nowadays, stochastic models are an important component of speech-recognition systems, enabling people to convey commands and information to computer systems.



Where we benefit today: PROTEIN STRUCTURE PREDICTION
NSF investment: NEURAL NETWORKS

Applications that can generate photo-quality images on demand. Software that can make pharmaceutical drugs more effective. Smartphones that can answer when you ask, "What's the weather?" Neural networks — computational models inspired by the wiring of human brains — make all this possible. Beginning in the 1980s, NSF-funded researchers at Bell Labs made a breakthrough when their neural networks recognized handwritten numbers. But even their best neural network algorithm couldn't tackle today's challenges; they took too long to adapt to new problems and were inaccurate. In the 2010s, some of the same researchers discovered how to use high-performance graphics processing units, like those used for video game image rendering, to increase the speed and accuracy of model training. Today, "deep" neural networks can be used to recognize and process speech, generate photo-quality images, and predict the structure of proteins from their molecular structure.



Where we benefit today: CHATBOTS
NSF investment: REINFORCEMENT LEARNING

How is a chatbot able to have a helpful, honest and harmless conversation with you? Taking inspiration from the way animals learn, researchers train the neural networks underpinning chatbots using an approach called reinforcement learning. Reinforcement learning algorithms "reward" certain actions more than others, causing them to be taken more often. Reinforcement learning can be used to design more efficient water treatment facilities, probe the roots of both creative and addictive behaviors, and optimize supply chains. NSF-funded researchers, like Andrew Barto of the University of Massachusetts, established the foundations of the field of reinforcement learning. He helped define the fundamental problem, provided bedrock algorithms for addressing it, and co-authored the first and most influential textbook describing the field. The result is a rich field of study with broad practical and scientific implications.

Where we benefit today: LANGUAGE-LEARNING APPLICATIONS
NSF investment: AI-DRIVEN LEARNING

With over 500 million registered users, Duolingo is one of the most popular language-learning applications in history. One of its core features is the use of artificial intelligence to personalize lessons for each learner. Duolingo's CEO, Luis von Ahn, was supported by NSF as a graduate student and as the early founder of the company. NSF invested directly in the science supporting AI-driven learning long before Duolingo's 2011 founding. In the 1980s, NSF supported the early science of intelligent tutoring systems, which seek to model the gap between what students can do and expert-level problem solving, as well as to determine actions that will help individual students grow their capabilities. Other examples of NSF investments in AI-driven learning include an award of over $25 million to the Pittsburgh Science of Learning Center for the establishment of the LearnLab. Today, NSF funds the AI Institute for Student-AI Teaming led by the University of Colorado Boulder, which is working to develop AI systems that partner with teams of students and their teachers to promote the development of AI literacy, STEM competencies and 21st-century learning practices of collaborative problem solving and critical thinking.

Where we benefit today: AI AND SOCIETY
NSF investment: TRUSTWORTHY AI

Recently, AI systems graduated from the research lab to easy-to-use applications like ChatGPT, Dall-E and Midjourney, allowing users to generate text and images using simple prompts. However, the full promise of AI-driven technology can only be safely harnessed if the underlying system is trustworthy. Anticipating the widening use and accessibility of AI systems, pioneering researchers like Sorelle Friedler, Solon Barocas, Suresh Venkatasubramanian and Julia Stoyanovich turned to NSF for support to study these issues in earnest. This led to considerable progress in identifying and isolating problematic ways of bringing AI technology to bear in the real world. These experts have been tapped to shape AI governance, from working for the White House to testifying before Congress and the U.S. Equal Employment Opportunity Commission. NSF continues to support research in trustworthy AI; the NSF Artificial Intelligence Institute for Trustworthy AI in Laws and Society, for example, focuses on issues such as the transparency, accountability and fairness of AI systems, as well as guidelines for building AI systems and collecting data more responsibly practices of collaborative problem solving and critical thinking.