“Linear algebra is the central subject of mathematics. You can’t learn too much linear algebra.”
B. Gross, former Dean of Harvard College

“The revolution of the 21st century [is] going to be to make medicine a computational science.”
M. Sachs, biomedical engineer

Why is linear algebra important? The 21st century is an age of data. In computer science, natural sciences, engineering, social sciences, and daily life, mountains of data are pervasive on a scale that would have been unimaginable at the end of the 20th century. Differential equations provided the mathematical framework for many of the advances of the 20th century, but linear algebra (the algebra and geometry of vectors and matrices in arbitrary dimensions) is the mathematical tool *par excellence* (alongside statistics) for the systematic analysis and management of the data-driven tasks of the 21st century. Even for modern applications of differential equations, linear algebra far beyond 3 dimensions is an important tool.

Stanford is unique among its peer universities in teaching “high-dimensional” linear algebra *alongside* multivariable differential calculus right from the start in its Math courses aimed at all students (not just future Math majors). You might wonder: why should I care about “high dimensions” (whatever that means), since we live in a 3-dimensional world? The reason is the following:

> *Many* contemporary real-world problems (in medicine, computer science, engineering, economics, physics, etc.) involve millions or even billions of variables that must be managed in a sensible way, and the only systematic way to handle this is via the language of high-dimensional linear algebra.

Here are some examples:

(i) Medical imaging and molecular biology techniques involving vast quantities of data have revolutionized medicine and biology. One such breakthrough, as described in [E1], harnessed insights from linear algebra with 1,000,000-*dimensional spaces* (applied to 1000×1000 pixel arrays). In 2017 a further speed-up was brought to market, impacting millions of MRI scans annually.

(ii) Machine learning and deep learning involve real-world optimization problems in zillions of unknowns that must be solved in a reasonably short time. This relies on the multivariable Chain Rule for functions of *any* number of variables (perhaps very very many), which can only be truly understood in an intuitive way via the framework of linear algebra we will teach you.

(iii) The crucial insight that made possible Google’s PageRank algorithm (and thereby so many subsequent webpage-ranking advances) was a synthesis of two fundamental concepts from linear algebra *taught in this course* – eigenvalues and Markov chains – applied to N-dimensional spaces with N on the order of **billions** (the total number of webpages on the Internet).