1. Data on graduation rates in math-intensive majors.

2. Data on high school and college mathematics enrollments.

3. The effect of calculus in high school.

4. What needs to change in our colleges and universities.
Over 600,000 students studied calculus in high school this year, roughly 1/3 of the 1.8 million who will go directly from HS to college.

Between 150,000 and 200,000 of these students earn and take advantage of credit for Calculus I.

CBMS and College Board data
Fall Enrollments, Calculus II (thousands)

4-year colleges
2-year colleges

CBMS data
Since 1995, there has been a **22% decrease** in the number of students taking Calculus II in the Fall term at comprehensive universities, undergraduate colleges, and 2-year colleges.

CBMS data
45% increase in 2-year college enrollments during this time

CBMS data
43% increase in 4-year college enrollments during this time

CBMS data
Calculus enrollments (thousands) by type of institution

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<tbody>
<tr>
<td>Research Univ</td>
<td>193.4</td>
<td>160</td>
<td>182</td>
<td>210</td>
</tr>
<tr>
<td>Comprehensive Univ</td>
<td>71.9</td>
<td>72</td>
<td>73</td>
<td>51</td>
</tr>
<tr>
<td>Undergrad College</td>
<td>107.4</td>
<td>105</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>2-year College</td>
<td>90</td>
<td>95</td>
<td>84</td>
<td>81</td>
</tr>
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</table>
Number of students (thousands) in 4-year undergraduate programs enrolled in mathematics at level of calculus or above (Fall term)
Number of students (thousands) in 4-year undergraduate programs enrolled in mathematics at level of calculus or above (Fall term)

- Research Universities
- undergrad/comprehensive

CBMS data
Increasingly, the students who do not have to take mathematics in college, don’t.
Bachelors Degrees, math-intensive majors

- Engineering
- Physical Science
- Math & Stat

NCES data
Math-intensive majors as % of Bachelors Degrees

- Engineering
- Physical Science
- Math & Stat

NCES data
Math-intensive Bachelor's degrees as % of 22 year-olds

Engineering
Physical Science
Math & Stat

NCES & US Census data
Women as % of Total Degrees

- All bachelor's degrees
- Engineering
- Mathematics
- Physical Science

NCES data
There were 1,089 Bachelors in Math or Stat earned by African-Americans in 1997. By 2009, that number was down to 876.
Controlling for socio-economic factors, what aspects of high school mathematics prepare students for success in Calculus I?
Numerous studies (Sadler and others) that control for ability (SAT/ACT) and socio-economic factors (e.g. parental education):

Students who study Calculus in HS and do well on placement exam (3+ on AB exam) do significantly better in Calculus I as well as intro Biology, Chemistry, and Physics.

There is little or no discernible benefit from simply taking Calculus in High School.
Bressoud, Carlson, Pearson, Rasmussen: *Characteristics of Successful Programs in College Calculus*

College factors that influence success in Calculus I and case study analysis of successful programs.
Random sample of 12,000 mainstream Calculus I students at all types of colleges and universities across the US (out of about 250,000):

• 61% took a calculus course in high school
  • 54% of these took an AP Calculus exam
    • 60% of those who took the AP Calculus exam earned a 3 or higher (94 students in the sample earned 5 on the BC exam)

• 10% are taking calculus in college for at least the second time
Of the high school students who graduated in 1992 and earned credit for “calculus” while in high school, 31% took *precalculus* in college, and a further 32% took *no calculus* in college.

Of the high school students who graduated in 2004 and earned credit for “calculus” while in high school, 17% took *remedial mathematics* in college.

NCES, NELS:88 and ELS:2002/06 data.
We must have clear, enforced guidelines for what it means to be ready for calculus in high school.

Of the high school students who graduated in 2004 and earned credit for “calculus” while in high school, 17% took remedial mathematics in college.

NCES, NELS:88 and ELS:2002/06 data.
Of students who took pre-calculus and
• Their declared major required at least one semester of calculus, and
• They earned an A in pre-calculus,

43% chose not to enroll in calculus.
During the period fall 2001 through fall 2006, 43% of engineering majors, 54% of mathematics majors, 51% of physical science majors, and 50% of technology majors who enrolled in Calculus I at ASU and whose intended majors required Calculus II never earned credit for Calculus II.
During the period fall 2001 through fall 2006, 43% of engineering majors, 54% of mathematics majors, 51% of physical science majors, and 50% of technology majors who enrolled in Calculus I at ASU and whose intended majors required Calculus II never earned credit for Calculus II.

The point is that ASU gathered this information, and they are now doing something about it.
SOLUTIONS: Improve first-year college mathematics

Use online resources to address individual student weaknesses.

Alison Ahlgren
SOLUTIONS: Improve first-year college mathematics

MA 103: Mathematical Modeling and Introduction to Calculus.
The course lays the foundation for calculus and differential equations through difference equations and dynamical systems.

This course has now been in place for twenty years.
A similar course at Macalester is over 5 years old.
MTBI supports the development of students through educational, research and mentorship activities from the undergraduate to the postdoctoral level.

Carlos Castillo-Chavez
“The mathematics profession as a whole has seriously underestimated the difficulty of teaching mathematics.”

Ramesh Gangolli
MER Workshop
May 31, 1991

With thanks to Susanna Epp for preserving this quote.

PowerPoint available at
www.macalester.edu/~bressoud/talks