The Great Diseases Partnership:

bringing cutting-edge biomedical science to the high school biology classroom

Karina Meiri and Berri Jacque
Massachusetts' STEM gap

Expanding the Pipeline for all 2013
Massachusetts’ biomedical STEM gap

9 out of 10 jobs in health and biology are in health
Three distinct cohorts:

- High level (PhD) need more diversity
- Mid-level – need more participants
- General population – needs better health literacy
Narrowing the STEM gap

- Engagement
- Preparation
### Engagement: How students value STEM

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find science helps me understand things around me</td>
<td>80%</td>
</tr>
<tr>
<td>Science is very relevant to me</td>
<td>66%</td>
</tr>
</tbody>
</table>

PISA 2007, 10th grade
How students value learning about things that affect them

<table>
<thead>
<tr>
<th>PERCENTAGE OF BOSTON HIGH SCHOOL STUDENTS* AGREEING OR STRONGLY AGREEING:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The importance of studying something that can affect your day-to-day behavior</td>
<td>100%</td>
</tr>
<tr>
<td>The value of studying something that can affect you directly</td>
<td>92%</td>
</tr>
</tbody>
</table>

*n = 124
Students especially value learning about health and disease

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<td>100%</td>
</tr>
<tr>
<td>The value of studying something that can affect you directly</td>
<td>92%</td>
</tr>
<tr>
<td>The value of studying diseases in general</td>
<td>98%</td>
</tr>
</tbody>
</table>

*n = 124
Narrowing the STEM gap

- Engagement
- Preparation
Preparation: Need practice to achieve advanced benchmarks

<table>
<thead>
<tr>
<th>Education system</th>
<th>Average</th>
<th>Low (&gt;400)</th>
<th>Intermediate (&gt;475)</th>
<th>High (&gt;550)</th>
<th>Advanced* (&gt;625)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>590</td>
<td>96%</td>
<td>87%</td>
<td>69%</td>
<td>40%</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>567</td>
<td>96%</td>
<td>87%</td>
<td>61%</td>
<td>24%</td>
</tr>
<tr>
<td>US</td>
<td>522</td>
<td>93%</td>
<td>73%</td>
<td><strong>39%</strong></td>
<td>9%</td>
</tr>
<tr>
<td>Ghana</td>
<td>396</td>
<td>22%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Advanced: Students apply knowledge and understanding of scientific processes and relationships and show some knowledge of scientific inquiry.

https://nces.ed.gov/TIMSS/
Preparation: need practice to solve problems in context

**Scientific Reasoning**

- **USA**
- **China**

**Mechanics**

- **USA**
- **China**

General scientific reasoning

Scientific reasoning in context

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3. Beijing Normal University, Beijing 100875, China.
4. Beijing Jiaotong University, Beijing 100044, China.
5. Baltimore, MD 21250, USA.
6. Department of Physics, The Ohio State University, OH 45435, USA.
7. Department of Physics, Tongji University, Shanghai 200092, China.
8. Nianle Wu
9. Tianfan Cai

**Comparison of Chinese and U.S. Students**

<table>
<thead>
<tr>
<th>Subject</th>
<th>USA</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity &amp; Magnetism</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Mechanics</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

In China, K–12 education is dominated by the amount of emphasis on conceptual physics. In contrast, K–12 physics education in the United States is more varied. Although every semester through grade 12, providing students go through the same physics course (other general science courses, only one of which is physics), students show differences on tests of physics content knowledge but not on tests of scientific reasoning. Content knowledge and reasoning skills diverge.

**Preparation**

Need practice to solve problems in context.

### General scientific reasoning

- **USA**
- **China**

### Scientific reasoning in context

- **USA**
- **China**

1st year college students

Solution?

Can we leverage student interest in health and disease to provide preparation that fosters Workforce participation and Health literacy?
How?

- Cohort 1 – High achievers who aren’t self-selecting.

- Cohort 2 – Midlevel participants who need exposure.

- Cohort 3 – General population, need health literacy.

To reach the largest population - need classroom-based intervention.
A collaborative approach to real-world science in the classroom

CTSE bridges the divide between biomedical scientists and K-12 educators, to bring the up-to-date science behind health and disease into the high school classroom.

The Center for Translational Science Education (CTSE) bridges the divide between biomedical scientists and K-12 educators, to bring the up-to-date science behind health and disease into the high school classroom. By building partnerships among specialists in biomedical science and health, teachers and educational researchers, we design, support implementation of, and rigorously evaluate life-relevant curricula, engaging students in authentic science practice, promoting self-efficacy in scientific problem solving, and impacting health literacy. Our partnerships among academic and industry researchers and teachers design and implement authentic research-based activities that promote the skill sets required for the diverse careers in biomedical and health sciences needed by 21st century economies.
The Great Diseases Project

- **Designs** engaging, rigorous, real world, health-focused biology curricula for 10th – 12th grade students

- **Provides** extensive support for teachers
The Great Diseases Partnership

A collaborative learning community
Curriculum development by partnership

Teachers
Pedagogical content knowledge
Assessments

Scientists
Novel content knowledge
Evidence-based reasoning

Life-relevant curricula

Engagement Performance
Workforce Preparation
Health Literacy
1. Engage the Boston Public Schools

Boston Latin School
Madison Park School
2. Curriculum development by partnership

<table>
<thead>
<tr>
<th>July 2009</th>
<th>July 2010</th>
<th>July 2011</th>
<th>July 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td><strong>Curriculum</strong></td>
<td><strong>Finalize</strong></td>
<td><strong>Enact</strong></td>
</tr>
<tr>
<td>Teacher text Seminar series</td>
<td>Objectives Unit structures Lessons Enactment (1)</td>
<td>Lesson plans Assessments Evaluations</td>
<td>Revise Differentiate Student workbooks Enactments (2-4)</td>
</tr>
<tr>
<td>Tufts content specialists</td>
<td>Tufts content specialists</td>
<td>Tufts content specialists</td>
<td>Teachers</td>
</tr>
<tr>
<td>Teachers</td>
<td>Teachers</td>
<td>Teachers</td>
<td></td>
</tr>
</tbody>
</table>

- **Total Phases:** 5
- **Participants:** Teachers, Tufts content specialists
- **Timeline:** July 2009 to July 2012
3. Module development and dissemination

- Infectious Disease: Dissemination (July 2009 - July 2015)
- Neurological Disorders: Dissemination (July 2009 - July 2015)
- Metabolic Disease: Dissemination (July 2009 - July 2015)
- Cancer: Dissemination (July 2009 - July 2015)
The Great Diseases Curriculum

An inquiry-based modular biology II curriculum for 10th – 12th graders

- Infectious diseases (2012)
- Neurological disorders (2013)
- Metabolic diseases (2014)
- Cancer (2015)
Module 1: Infectious Disease
35 comprehensive lessons

Unit 1: Why should we care about infectious disease?
Unit 2: What does it mean to have an infectious disease?
Unit 3: When does a microbe become pathogenic?
Unit 4: How do pathogens make us sick?
Unit 5: How do we get better?
Overall lesson format:

1. Do Now
   - Do now
     - Using your Ghost Map homework as a guide, what would you expect to observe if a disease is contagious?

Ask the students:
What are the four problems that must be solved?
1. We need to prove that the disease can spread from person to person.
2. We need to be able to associate the disease outbreak with a source of infection.
3. We need to isolate an infectious agent that is found at both the source of the infection and in the infected person.
4. We need to show that the infectious agent we have isolated can cause disease.

2. Activity
   - In the Phenolphthalein simulation the students use correlations to pinpoint the source of spread of the indicator chemical.
   - Activity
     - Using phenolphthalein to simulate infectious spread.

After the activity analyze the spread of the indicator solution to disease and guide the students to think about how population characteristics affect the spread.

Ask the students:
How would increase in the human population affect diseases spread by contact?
- Increased population density will force more people into contact with each other.
- Increased population density may force more people to expand into new habitats where they will encounter novel infections.

3. Wrap Up
   - What principle can we use to tell whether a disease is infectious?
     - Robert Koch

Important points:
- If you are running behind, this slide and the rest can be moved to the next lesson.
- Returning to the idea of correlation and causation. In the activity it was clear that the appearance of color in one cup was caused by adding liquid from another cup. This is causation.
- In reality causation is not so evident because we usually can’t see the transfer of infectious agents.
Multiple inquiry-based pedagogies

Lessons:

- Socratic discussions
- Student-led teach-backs (jigsaws)
- Small group work
- Projects

Labs:

- Hands-on
- Interrupted case studies
The biomedical teaching gap

- Teachers also have limited biomedical and health literacy

- Addressing the problem:

  Modeling for Fidelity (MFF)
Professional development

Best practices
- Extended duration
- Contextualized rich in content
- Sustained mentor interactions

Actual practices
- Limited duration
- Focus on pedagogy
- Limited mentor interactions
Professional development in-person and online

**Benefits of In-Person PD**
- Provides easy access to experts
- Allows for peer collaboration
- Encourages hands-on experience
- Builds collegiality between teachers

**Benefits of Online PD**
- Accommodates teachers’ busy schedule
- Provides access to resources not available locally
- Provides real-time, work-embedded support
- Does not require assembly of teachers for single meeting

**Modeling for Fidelity**
Modeling for Fidelity

**Teach**
- Classroom management
- Formative assessment

**Prepare**
- Content
- Pedagogy
- Materials

**Reflect**
- Questions
- Assessments
- Redesign
Modeling for Fidelity

Prepare
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Modeling for Fidelity

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- Content
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Reflect
- Questions
- Assessments
- Redesign

Lesson plans
Student workbooks

Student workbooks

Teacher text
Modeling for Fidelity

Prepare
- Content
- Pedagogy
- Materials

Teach
- Classroom management
- Formative assessment

Reflect
- Questions
- Assessments
- Redesign

Contextualized content tutorials
Teacher text

Just-in-time support
Lesson plans
Student workbooks

Just-in-time support
Student workbooks
Modeling for Fidelity

Prepare
- Content
- Pedagogy
- Materials

Teach
- Classroom management
- Formative assessment

Reflect
- Questions
- Assessments
- Redesign

Contextualized content tutorials
Teacher text

Just-in-time support
Lesson plans
Student workbooks
Teacher scrapbook
Videos of lessons
Discussion forum
News blog

Discussion forum
Student workbooks
Just-in-time support
How do we measure the quality of MFF?

• **Direct** - change in teacher practices in the classroom
  – Teacher self-reporting
  – Observation

• **Indirect** - student outcomes
  – Performance
  – Engagement
How do we measure the quality of MFF?

• **Direct** - change in teacher practices in the classroom
  – Teacher self-reporting
  – Observation

• **Indirect** - student outcomes
  – Performance
  – Engagement
What we measure:

- **Student engagement**
  - Attitude

- **Student Performance**
  - Conceptual content knowledge inventory
  - Problem solving skills

- **Health literacy**
  - Self-efficacy
  - Claims evaluation and risk assessment skills
What is the first word that comes to mind about the Infectious Disease module?

*Data from 3 schools*
## Conceptual content knowledge and problem solving skills

![Graph showing improvement in knowledge and skills](image)

<table>
<thead>
<tr>
<th>Module</th>
<th>Average Pre (SD)</th>
<th>Average Post (SD)</th>
<th>Effect Cohen’s d</th>
<th>Chronbach Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID (n = 286)</td>
<td>18.8 (12.6)</td>
<td>48.0 (19.7)***</td>
<td>1.8</td>
<td>0.86</td>
</tr>
<tr>
<td>ND (n = 142)</td>
<td>19.5 (7.9)</td>
<td>62.9 (14.9)***</td>
<td>3.6</td>
<td>0.81</td>
</tr>
<tr>
<td>MD (n = 160)</td>
<td>20.6 (11.0)</td>
<td>70.5 (15.5)***</td>
<td>3.7</td>
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Conceptual content knowledge and problem solving skills

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</tr>
</tbody>
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***p<0.0001
ID content knowledge and problem solving skills by school

Gold Standard PD

- Urban Exam (MA)
- Urban General (MA)

Modeling for Fidelity

- Suburban General (MA)
- Regional STEM (OH)

***p<0.0001

Berri Jacque
ND content knowledge and problem solving skills by school

Gold Standard PD

Urban Exam (MA)

Modeling for Fidelity

Regional STEM (OH)

Urban General (MA)

Suburban General B (MA)

***p<0.0001
## Knowledge and problem solving: Gold standard vs MFF PD

<table>
<thead>
<tr>
<th>School</th>
<th>Pre</th>
<th></th>
<th>Post</th>
<th></th>
<th>Cohen's d</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>(SD)</td>
<td>Mean</td>
<td>(SD)</td>
<td></td>
</tr>
<tr>
<td><strong>Infectious Diseases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban Exam High School</td>
<td>22.9</td>
<td>11.7</td>
<td>56.2</td>
<td>12.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Suburban High School A</td>
<td>15.7</td>
<td>10.2</td>
<td>54.9</td>
<td>14.9</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Urban High School</strong></td>
<td>5.8</td>
<td>7.9</td>
<td>30.4</td>
<td>16.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Regional STEM High School</td>
<td>14.3</td>
<td>10.4</td>
<td>46.2</td>
<td>19.9</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18.9</td>
<td>12.6</td>
<td>48.0</td>
<td>19.7</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Neurological Disorders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban Exam High School</td>
<td>19.1</td>
<td>7.5</td>
<td>65.3</td>
<td>13.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Suburban High School B</td>
<td>21.4</td>
<td>9.6</td>
<td>51.3</td>
<td>17.6</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Urban High School</strong></td>
<td>11.3</td>
<td>7.6</td>
<td>37.4</td>
<td>14.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Regional STEM High School</td>
<td>18.9</td>
<td>9.6</td>
<td>60.1</td>
<td>12.0</td>
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<tr>
<td><strong>Total</strong></td>
<td>18.6</td>
<td>8.3</td>
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<td>16.3</td>
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</tr>
</tbody>
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### Self-efficacy

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<thead>
<tr>
<th>Module</th>
<th>Average Pre (SD)</th>
<th>Average Post (SD)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ID (n = 293)</td>
<td>23.0 (8.9)</td>
<td>41.0 (8.0)***</td>
<td>2.12</td>
<td>0.90</td>
</tr>
<tr>
<td>ND (n = 269)</td>
<td>17.0 (7.1)</td>
<td>37.7 (8.7)***</td>
<td>2.61</td>
<td>0.93</td>
</tr>
<tr>
<td>MD (n = 125)</td>
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<td>40.7 (7.2)***</td>
<td>2.55</td>
<td>0.90</td>
</tr>
<tr>
<td>Comparison (n = 124)</td>
<td>23.1 (8.1)</td>
<td></td>
<td></td>
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</tr>
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</table>

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<td></td>
<td></td>
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</tbody>
</table>

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## Self-efficacy instrument

<table>
<thead>
<tr>
<th>Description</th>
<th>Before Mean</th>
<th>After Mean</th>
<th>Comparison Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>My understanding of how infectious diseases begin</td>
<td>2.38 (1.1)</td>
<td>4.75 (1.1)</td>
<td>2.39 (1.2)</td>
</tr>
<tr>
<td>My understanding of how infectious diseases spread</td>
<td>2.89 (1.2)</td>
<td>4.97***</td>
<td>3.25 (1.3)</td>
</tr>
<tr>
<td>My skills at identifying an infectious disease</td>
<td>2.11 (1.1)</td>
<td>4.35***</td>
<td>2.20 (1.0)</td>
</tr>
<tr>
<td>My skills at making accurate judgments about infectious diseases</td>
<td>2.15 (1.0)</td>
<td>4.23***</td>
<td>2.26 (1.1)</td>
</tr>
<tr>
<td>My skills at how to find correct information about infectious disease</td>
<td>2.57 (1.3)</td>
<td>4.53***</td>
<td>2.93 (1.4)</td>
</tr>
<tr>
<td>My understanding of how to connect different data to form an hypothesis about an infectious disease</td>
<td>3.32 (1.1)</td>
<td>4.27***</td>
<td>2.46 (1.3)</td>
</tr>
<tr>
<td>My skills at using data to understand infectious disease</td>
<td>2.32 (1.2)</td>
<td>4.20***</td>
<td>2.44 (1.3)</td>
</tr>
<tr>
<td>My knowledge of how the body works to prevent the spread of infectious disease</td>
<td>2.65 (1.2)</td>
<td>4.83***</td>
<td>2.73 (1.2)</td>
</tr>
<tr>
<td>My knowledge of how the environment affects the spread of infectious disease</td>
<td>2.53 (1.2)</td>
<td>4.65***</td>
<td>2.70 (1.3)</td>
</tr>
<tr>
<td>Total (54 points)</td>
<td>21.78 (8.31)</td>
<td>40.54***</td>
<td>22.8 (9.0)</td>
</tr>
</tbody>
</table>
## Principal components analysis (PCA)

<table>
<thead>
<tr>
<th>My understanding of how infectious diseases begin</th>
<th>One Year Ago</th>
<th>Currently</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.74</td>
<td>0.88</td>
</tr>
<tr>
<td>My understanding of how infectious diseases spread</td>
<td>0.76</td>
<td>0.84</td>
</tr>
<tr>
<td>My skills at identifying an infectious disease</td>
<td>0.86</td>
<td>0.83</td>
</tr>
<tr>
<td>My skills at making accurate judgments about infectious diseases</td>
<td>0.77</td>
<td>0.82</td>
</tr>
<tr>
<td>My skills at how to find correct information about infectious diseases</td>
<td>0.72</td>
<td>0.82</td>
</tr>
<tr>
<td>My understanding of how to connect different data to form an hypothesis about an infectious disease</td>
<td>0.79</td>
<td>0.85</td>
</tr>
<tr>
<td>My skills at using data to understand infectious diseases</td>
<td>0.80</td>
<td>0.86</td>
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<td>My knowledge of how the body works to prevent the spread of infectious disease</td>
<td>0.74</td>
<td>0.87</td>
</tr>
<tr>
<td>My knowledge of how the environment affects the spread of infectious disease</td>
<td>0.74</td>
<td>0.80</td>
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</tbody>
</table>

### Reliability Statistics

<table>
<thead>
<tr>
<th>Reliability Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambda</td>
<td>0.97</td>
</tr>
<tr>
<td>Cronbach's Alpha</td>
<td>0.91</td>
</tr>
</tbody>
</table>
## Self-Efficacy: Gold standard vs MFF

<table>
<thead>
<tr>
<th>School</th>
<th>Pre</th>
<th>Post</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infectious Diseases</strong></td>
<td>Mean</td>
<td>(SD)</td>
<td>Mean:</td>
</tr>
<tr>
<td>Urban Exam High School</td>
<td>22.1</td>
<td>8.4</td>
<td>41.2</td>
</tr>
<tr>
<td>Suburban High School A</td>
<td>24.4</td>
<td>8.8</td>
<td>40.2</td>
</tr>
<tr>
<td><strong>Urban High School</strong></td>
<td>18.8</td>
<td>6.7</td>
<td>41.5</td>
</tr>
<tr>
<td>Regional STEM High School</td>
<td>21.2</td>
<td>8.9</td>
<td>39.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>21.8</td>
<td>8.3</td>
<td>40.5</td>
</tr>
</tbody>
</table>

| **Neurological Disorders**          | Mean | (SD)  | Mean:     | (SD)  |     |
| Urban Exam High School              | 17.3 | 7.0   | 37.8      | 8.7   | 2.6 |
| Suburban High School B              | 16.8 | 8.0   | 36.1      | 8.0   | 2.4 |
| **Urban High School**               | 19.2 | 9.1   | 42.7      | 9.6   | 2.5 |
| Regional STEM High School           | 16.9 | 7.7   | 33.3      | 11.6  | 1.7 |
| **Total**                           | 17.0 | 7.1   | 37.7      | 8.7   | 2.2 |
Does the health knowledge leave the classroom?

*p<0.05
The next step is scaling up

New tools to measure outcomes

Interactive + assessments

Just-in-time support
Lesson plans
Student workbooks
Teacher scrapbook
Videos of lessons
Discussion forum
News blog

Teacher networking

Prepare
• Content
• Pedagogy
• Materials

Teach
• Classroom management
• Formative assessment

Reflect
• Questions
• Assessments
• Redesign

Contextualized content tutorials
Teacher text

Create online courses

More resources between tutorial and teaching

Come to tutorials more prepared
# The Great Diseases partners

**CTSE**
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- Berri Jacque PhD
- Dessy Raytcheva PhD
- Katherine Malanson PhD
- Ravi Subramanian PhD
- Nicholas Sylvain PhD
- Stephanie Tammen PhD
- Anne Vera Cruz MA
- Jenna Reece BS
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- Jared Hawkins PhD
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- Sapna Sharma MS
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- Michele Tangredi PhD
- Amy Thurber
- Laura Wong PhD
Questions and thoughts?

http://sites.tufts.edu/greatdiseases/
User name: iduser
Password: id?sick