Teacher Guide

Engineering Tomorrow

Pharmaceuticals:

Designing & Producing Effective Medicines

NEW FOR 2025-2026!

- ★ Relevant real-world examples added: Youtube videos on painkillers including Ibeprofen and acetaminophen
- ★ Relevant real-world examples added: Youtube videos on the drug discovery process
- ★ Quality check was performed to ensure web links still work and equipment lists are up to date.

SUGGESTED LESSON PLAN - 50 minute periods	
Total Time ~75-100 minutes • 27 minutes to watch the lab introduction video • 20-30 minutes to build and test their drug delivery system • 20-30 minutes to build a second iteration • ~5-10 minutes closing activity or discussion Optional Extension: • Biological Drug Processing and Cell Fermentation ***Important: Schedule a 30-45 min Zoom session at your designated class time and meet with an Engineer and College Engineering Student. We will meet your class wherever they are: Introducing the lesson, Building & designing, Testing, or Analyzing results.***	
Hook/Essential Question	**Why might drugs be administered in different ways, like by mouth or by injection?**
Supplies to Have in Class	ET Pharmaceuticals Kit materials can be found at the end of this file. • colored tablets, water soluble stabilizers, napkins Additional Items to Consider Having on Hand: • Water • Paper Towels to clean up any spills • Sink, drain, or bucket to dump liquid at the end of the lab • Other types of paper to test and/or tape to secure the tablets **NOTE:** The videos **below** should be unblocked for **teachers-only** if presenting the student workbook to the whole class OR for **all students** if they are completing the student workbook on their school devices Main Workbook ➔ https://www.youtubeeducation.com/watch?v=bNYc5JHfsqs ➔ https://www.youtubeeducation.com/watch?v=u0E7TDmHBqM ➔ https://www.youtubeeducation.com/watch?v=6YXag5oNU6k ➔ https://www.youtubeeducation.com/watch?v= Oxos77fIsmc *(Optional Extension #1)*

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	➔ https://www.youtubeeducation.com/watch?v=5eKdZ0dVCCo
Class #1 Introduction and Procedure	Watch the Engineering Tomorrow: Pharmaceuticals Intro Recording on the Pharmaceuticals webpage either as a class or assign background section as pre-work (see above). ➔ Have students answer the comprehension questions in the first 31 slides of the student workbook ➔ Watch the rest of the video that outlines the instructions for the challenge. Student teams begin to build and test drug delivery prototypes → research designs, review materials, test the initial design concepts and describe in their student workbook or worksheet *(1 workbook or worksheet per team suggested)*
Class #2 Work Time and Testing	➔ Complete Prototypes #1 and 2 if not already done in previous class ➔ Determine Final Prototype Design and Test It ➔ Students measure the performance and determine which of the 3 designs was the best at matching a 5-second and a 30-second medicine delivery system. ➔ Student teams summarize and reflect on their final plane design and performance in the workbook or worksheet
Part of Class #3 Possible Closing Questions and Activities	Class Discussion Question: As more and more people suffer from cancer, what other types of medications and treatments are you aware of? Or watch the inspiring Keynote Speaker Video: (~25:00 -1:14:00) featuring a Q&A with ET's Milton Davis and Dr. Liagliang Hao, leading expert in cancer technology, at the Koch Institute. https://www.youtube.com/watch?v=9_ASw20sNWE

INTRODUCTION TO ENGINEERING TOMORROW:

- Click here to see an introduction of what Engineering Tomorrow can do for your students.

INTRODUCTION TO THE ENGINEERING DESIGN PROCESS:

- Students should complete the Engineering Design Process Introduction Activity before starting the lab
  - NOTE: This activity only needs to be completed before the student's **first** ET lab, not repeated for every lab.

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TEACHER NOTES:

- Students will work through the **Pharmaceuticals:** Student Workbook or complete the Abbreviated Student Worksheet.
    - When assigning this lesson on Google Classroom, first make a copy of the slides to save within your Google Drive, then assign so that each student has their own copy.
    - The workbook and worksheet are designed to be interactive so that students can type directly into the files. It is suggested that the workbook or worksheet be completed over a few class periods (as the information is delivered to students).
    - Students may work individually or within groups (at the discretion of the instructor).

ASSESSMENT:

- Informal assessments can be completed by looking at the reflection slides within the Student Workbook and/or the discussion questions in the Abbreviated Worksheet.

- **Answer Keys** for the Student Workbook or Student Abbreviated Worksheet can be given upon teacher request.

PRE AND POST WORK IDEAS:

- Pre-work Assignment - students watch an 8 min video that briefly highlights methods of drug administration

EXTENSION ACTIVITIES:

- Play Quizlet or Kahoot to review concepts concerning drug delivery

ADDITIONAL TEACHING REFERENCES	
Curriculum Connections: • Aligns with chemistry and biology curriculums in high school • Chemical Engineering: using math, science, and engineering concepts to design an enteric coating to delay the release of colored tablets inside the human body • Biomedical Engineering: designing and constructing drug delivery devices	**Students will be able to:** • Analyze real-world problems and use critical thinking skills in order to solve them • Explore developments in drug delivery systems • Design and build a small-scale dual delayed drug release delivery system using material provided • Explain the engineering process as it pertains to their design and reflect on opportunities to improve it

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Content Vocabulary/Terms:

- Pharmaceuticals: chemical substances used for the prevention or treatment of a disease, and to help restore or correct functions in the body
- Drug Delivery Systems: engineered technologies for the targeted delivery and/or the controlled release of the active pharmaceutical ingredient in the human body
- Diffusion Flux: the movement of particles
- Fick's First Law of Diffusion: diffusion flux from high to low concentration is directly proportional to the particle's concentration gradient
- Polymers: materials of long, repeating chains of molecules

NEXT GENERATION SCIENCE STANDARDS:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing temperature or concentration of the reacting particles on the rate at which a reaction occurs.

MATERIALS:

TEACHER'S KIT		
Materials will be distributed throughout the class.		
Item/Link	**Quantity**	**Photo**
Box of Paper Clips	1	
Colored Tablets	1 jar (≤30 students) and 2 jars (>30 students)	

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Materials Cont.→

STUDENT KIT ITEMS		
1 kit: 3 students		
Item/Link	**Quantity**	**Photo**
Paper Strips	10	
Napkin	1	