Opentrons
for Education

Prep Sheet

Drafting Protocols with OpentronsAI

Kennedy Bae, Ph.D. and Emily Burghardt, Ph.D.

Opentrons

Getting Started

Complete the following steps prior to class:

- ☐ Visit ai.opentrons.com in your Chrome browser and set up an account.
- ☐ Practice prompting OpentronsAI to write a protocol.

New to Opentrons?

Opentrons is on a mission to put laboratory automation in the hands of today's students and the educators that shape their future. You can join our education initiative at Opentrons for Education.

The following resources and tutorials can help you set up your Opentrons equipment before class.

- ☐ Set up the Opentrons app
- ☐ Import an protocol into the Opentrons App
- ☐ Flex Instruction Manual
- ☐ OT-2 Instruction Manual

Need Additional Support?

For technical support, check our Opentrons Help Center for relevant articles. If you need further support, please contact support@opentrons.com. Inform them that you are a part of the Opentrons for Education program and provide the date of your next laboratory class.

If you have questions related to the lesson plan, please reach out to Emily Burghardt at emily.burghardt@opentrons.com.

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Educator Guide

Drafting Protocols with OpentronsAI

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Opentrons

Purpose

This lab develops student understanding of AI tools like OpentronsAI in life science laboratories.

During this lab class, students will learn about and gain experience with:

- Building and troubleshooting laboratory protocols
- Comparing manual and AI-generated protocols
- Identifying limitations and strengths of AI in a laboratory setting

Student Audience

This lab is designed for use in undergraduate biology courses. It can be adapted to accommodate different class sizes.

Background Knowledge

Students should have a conceptual understanding of basic laboratory protocols, Python coding, and the use of automated liquid handling systems.

Core Competencies

Laboratory Skills

- Coding and protocol development
- Use of laboratory automation equipment

Critical Thinking

- Compare manual and AI-generated protocols
- Troubleshoot and correct errors
- Interpret capabilities and limitations of AI applications
- Decision-making based on protocol analysis

Supplies

Opentrons Equipment

- [ ] OpentronsAI

Non-Opentrons Equipment

- [ ] Computer with internet access
- [ ] Chrome browser

Experimental Duration

Required Class Sessions

1

Lab Run Time

Estimated total time: 3-4 hours

- Introduction: 20 minutes
- Building a protocol: 1.5 hours
- Troubleshooting a protocol: 1 hour
- Identifying the limits of AI: 1 hour
- Discussion: 10 minutes

To save time in class, assign students to write their manual protocol before class. For more, see the **Building a protocol** section in the Procedure Guide.

Basic Troubleshooting and Tips

- We recommend completing a trial run before class to identify and resolve any issues.
- OpentronsAI is only supported in Google Chrome.
- Visit our Opentrons Python API for guidance on writing Python protocols for Opentrons robots.
- OpentronsAI only provides complete responses (Python protocols). Students will need to wait until the full response is generated to see the results of a prompt.
- OpentronsAI can make mistakes. Review your protocol before running it on an Opentrons robot.
- The sample transfer in this lesson can be performed with an Opentrons single channel pipette. Students should include an Opentrons Flex or OT-2 1 single channel pipette in their OpentronsAI prompt.
- Students can ask OpentronsAI to simulate any protocol in this lesson plan, whether manually written or

OpentronsAI-generated. Ask OpentronsAI to simulate your protocol in the chat or click **Update an existing protocol** on the OpentronsAI home screen to import and analyze an existing protocol.

You can also import any protocol into the Opentrons App to check for errors. If your OpentronsAI protocol fails analysis in the app, students can use the app's error details as another prompt in the chat. OpentronsAI will provide an explanation of the error and an updated protocol.

- Instructors and students can report prompts that OpentronsAI was unable to implement by clicking the thumbs down icon in any response from OpentronsAI. Include a written description of the issue to send feedback.

Procedure Guide

Before Class

1. Create a Python protocol with an intentional error for students to use in **Troubleshooting a protocol.**
2. Create an OpentronsAI account and submit prompts to test the lesson plan, chat feature, and AI-generated protocols.

Lab Introduction

Instructors may wish to define AI (artificial intelligence) and cover uses in the lab and in our everyday lives. Examples include:

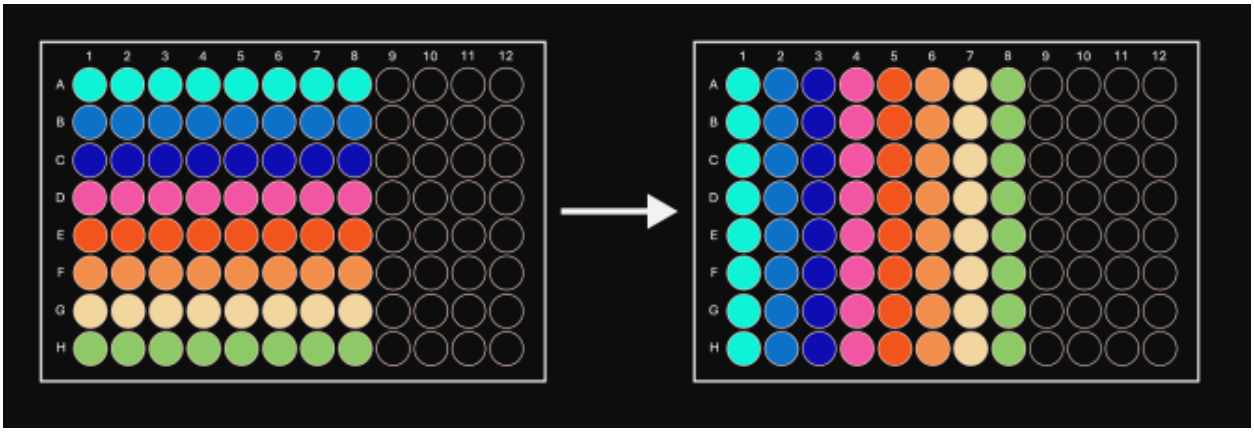
- **Analyzing scientific data:** identifying promising genes from thousands in sequencing data
- **Writing text or code:** writing a scientific protocol for your Opentrons robot from a text description
- **Making recommendations:** suggesting your next video or movie on streaming platforms
- **Answering questions:** answering user questions in a chat or summarizing a large number of answers on a search engine

Depending on student level and interest, instructors can provide more information on AI types and theory.

Building a protocol

Activity 1.1- Students manually write a sample transfer protocol

1. Students should open a new Python file in a code editing program.
2. Students will manually code a transfer of 50 µL of sample from one well plate to another. The samples should be transferred as shown below.



Here, samples from row A (in wells A1-A8) are transferred into column 1 (wells A1-H1). The process is repeated for rows B-H.

Activity 1.2- Students recreate the protocol using OpentronsAI

1. Students should use OpentronsAI to generate a protocol for the same process they manually coded.

   Remind students to fill out the form completely. Example prompts are shown below:

   - **Scientific application:** Basic aliquoting
   - **Description:** The protocol transfers samples from one plate to another and transforms samples to a new location (samples from row A, wells A1-8, are transformed into column 1, wells A1-H1).

- **Instruments:** Opentrons Flex, Flex 1-channel 50 µL pipette. The Flex gripper and modules are not required for this protocol.
- **Labware:** two 96-well plates, like the NEST 96 Well Plate 200 µL Flat, and Opentrons Flex 200 µL tips
- **Liquids:** Specify the wells of the source plate the samples should be added to. We recommend including prompts like the following for each sample:
  "Add 60 µL of sample 1 to wells A1-8 of the source NEST well plate."
- **Steps:** Add individual steps like the following for each sample transfer:
  "Transfer 50 µL of sample 1 from wells A1-A8 in the source NEST well plate to wells A1-H1 of the destination NEST well plate."

2. Students should confirm their choices and text before submitting their prompt.
3. Guide students to compare and contrast their manual and OpentronsAI-generated protocols.
4. Students should list strengths, weaknesses, and potential improvements for each protocol. Did OpentronsAI optimize the transfer or use a method the students did not? Are there errors in either protocol?

Troubleshooting a protocol

Activity 2.1- Students correct an intentional protocol error

1. Students will use a pre-designed protocol with an intentional error (made before class).
2. Students can use their lab notebook to summarize the process being automated by the protocol. What is the scientific application? What actions does the robot perform?
3. Give students time to find and fix the error manually. How many errors are present? What would happen if the error wasn't fixed?

Activity 2.2- Students correct the error with OpentronsAI

1. Direct students to use OpentronsAI to detect the error in the protocol. Students should upload their protocol and prompt OpentronsAI to find and correct the error.
2. Discuss with students the differences in error identification. Was it difficult to find the error themselves?

What are the limits of AI?

1. Encourage students to submit complex prompts to OpentronsAI to test its limits.
    a. Report prompts that OpentronsAI was unable to implement by clicking the thumbs down icon on any OpentronsAI response. Students should include a written description of the issue to send feedback.

Discussion Questions

Direct students to discuss the lab and uses of AI with their labmates. Example prompts might include:

- Which tasks was OpentronsAI most efficient for? Was there a task it struggled with?
- Can you think of a scenario where it would be better to manually code? What tasks is AI-generated protocol more efficient for?
- What are your thoughts on using AI in the lab?

Lab Report

Assign students to prepare a comprehensive lab report. Their reports should include:

- Comparison of their manual and OpentronsAI-generated protocols

- Error analysis and troubleshooting steps taken in class
- A reflection on the limitations and strengths of OpentronsAI
- Lab applications where AI could be beneficial or detrimental

Provide guidelines for report structure and data presentation. Encourage students to add their own thoughtful reflections on the lab class.

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Student Guide

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Purpose

Automation and AI tools are increasingly used, from your favorite search engine or streaming platform to the research lab.

This lab introduces the use of AI tools, like OpentronsAI, in the lab. You can use different methods to create protocols for an Opentrons robot:

- Manually write a Python protocol using the Opentrons Python Protocol API .
- Prompt OpentronsAI to generate a Python protocol for your experiment.

In this lab, you'll compare and contrast the methods and consider the use of AI at the bench.

Learning Outcomes

- Build and troubleshoot a laboratory protocol
- Compare manual and AI-generated protocols
- Identify limitations and strengths of AI in a laboratory setting

Supplies

Opentrons Equipment

- ☐ OpentronsAI

Non-Opentrons Equipment

- ☐ Computer with internet access
- ☐ Chrome browser

Procedure Guide

Before Class

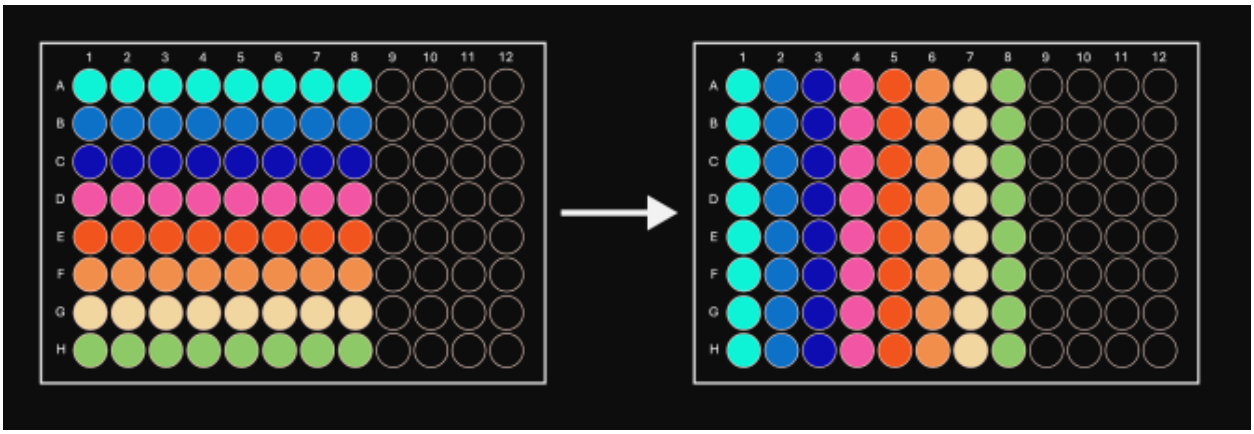
1. Write an Opentrons protocol manually before class if your instructor directs you to do so. For more, see the **Building a protocol** section.

Building a protocol

Activity 1.1 - Manually write a sample transfer protocol

1. Open a new Python file in a code editing program.

2. Use the Opentrons Python Protocol API to manually code a transfer of 50 µL of sample from one well plate to another. The samples should be transferred from the source to destination plate as shown below.



Here, samples from row A (in wells A1-A8) are transferred into column 1 (wells A1-H1). The process is repeated for rows B-H.

Activity 1.2 - Recreate the protocol using OpentronsAI

1. Use OpentronsAI to generate a protocol for the same process you manually coded.

   You'll need to fill out the form *completely.* When in doubt, provide more information!
   - Choose a **scientific application** from the dropdown menu.

- Write a **description** of your protocol. When in doubt, provide more information than you think you need.
- Choose your **instruments:** robot and pipettes. The Flex gripper and modules are not required for this protocol.
- Add **labware:** two 96-well plates and tips to complete the liquid transfers.
- Add your **liquids:** Specify where your samples are in the source plate when the protocol starts. Remember to provide information like volume (in microliters) and specific wells.
- Add individual **steps** for each sample transfer. You should include volume and specific source and destination wells for the transfer. This should be *more* detailed than your protocol description.

2. Confirm your choices and step and liquid descriptions before submitting the prompt.
3. You may need to wait a minute to see a response from OpentronsAI. A typical response includes a summary of your prompt, any decisions OpentronsAI made for you (like locations on the deck), and your protocol!
4. Click in the bottom right corner of the response to download your protocol.

5. Compare and contrast your manual and OpentronsAI-generated protocol. List the strengths, weaknesses, and potential improvements for each:
    - Did OpentronsAI optimize the transfer, or use a method that you didn't?
    - Are there errors in either protocol? You can ask OpentronsAI to simulate your protocol or upload into the Opentrons App to check for errors.

Troubleshooting a protocol

Activity 2.1 - Correct a protocol error

1. Your instructor made a protocol for you before class that includes an error. Use your lab notebook to summarize the process being automated by the protocol.
    - What is the scientific application?
    - What actions does the robot perform?
2. Try to find the error in the protocol yourself. Remember that there may be more than one error.
    - How many errors did you find?
    - What would happen if the error wasn't fixed?

Activity 2.2 - Correct a protocol error with OpentronsAI

1. Next, use OpentronsAI to detect the error in the protocol. Open a new OpentronsAI window and click **Update an existing protocol.**
2. Upload the protocol your instructor wrote. This is a unique update, so choose “other” from the dropdown menu.

   Include a written prompt to direct OpentronsAI to find and correct the error in your protocol.
   3. Discuss with your labmates and instructor. Was it difficult to find the error yourself? Was anything different when you used OpentronsAI to find the error?

What are the limits of AI?

Submit complex prompts to OpentronsAI to test its limits. What *can* OpentronsAI do beyond the protocol you developed in lab?

Report prompts that OpentronsAI is unable to implement by clicking the thumbs down icon on any OpentronsAI response. Include a written description of the issue to send feedback.

Discussion Questions

Discuss the lab and use of AI with your labmates.

- Which tasks was OpentronsAI most efficient for? Was there a task it struggled with?
- Can you think of a scenario where it would be better to manually code? What tasks is AI-generated protocol more efficient for?
- What are your thoughts on using AI in the lab?

Lab Report

Prepare a lab report based on today's activities. Your report should include:

- Comparison of your manual and OpentronsAI-generated protocols
- Error analysis and troubleshooting steps taken in class
- Your thoughts on the limitations and strengths of OpentronsAI
- Lab applications where AI could be beneficial or detrimental