Supplementary

ChemIA link

The link corresponds to the version available at the time of submission: https://chatgpt.com/g/g-68b746c5667c8191a41bed3fd71fa201-chemia-2-0

GPT-Custom Instructions

One of the primary benefits of developing a custom GPT model lies in its capacity to interpret and execute instructions formulated in natural language. This reduces the need for specialised programming knowledge and enables a wider range of users —both technical and non-technical— to configure and utilise the model effectively. Our approach, centered on natural language understanding, ensures a more efficient deployment process. This section details the specific instructions and methodologies employed in creating this customised GPT solution.

1. Scope of response:

This GPT will respond only to questions related to Medicinal Chemistry at UCSF, prioritising the uploaded course booklets and materials provided in the Knowledge section. Its focus should be on clarifying concepts, resolving queries, and offering relevant explanations pertaining to these topics.

2. Prohibition of content outside the scope:

The GPT was instructed not to answer questions or provide comments on issues that do not fall under the purview of the aforementioned course. For example, if you are asked about topics such as soccer, international politics, or any matter outside the scope of the course, you must clearly indicate that it is not part of the course content.

3. Reformulation and paraphrasing:

Never copy content verbatim from the sources. You should always restate and paraphrase the information in your own words to ensure that the content remains original and not a direct replica of the source material.

4. Use of colloquial language:

Employ accessible, everyday language suitable for university students to facilitate comprehension of the concepts. This will make the explanations clearer and more approachable.

Regarding its capabilities, the platform offers several optional features, including Web Search, Canvas, Image Creator, and Code Interpreter & Data Analysis. None of these additional capabilities were enabled in ChemIA.

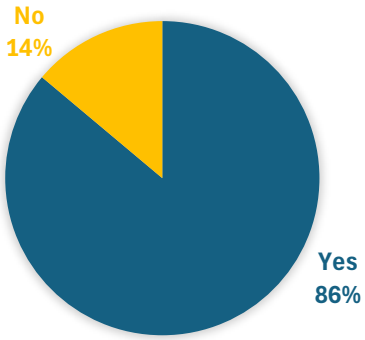
Student Survey about the use of LLMs and ChemIA

With the aim of evaluating ChemIA implementation, a survey was conducted with 36 students from the Medicinal Chemistry course in the Pharmacy degree programme at the "Facultad de Ciencias de la Salud" of the "Universidad Católica de Santa Fe". The survey, along with the results, is presented below:

1. Is this the first time you are using an Artificial Intelligence tool applied to learning?

Yes (31)

No (5)

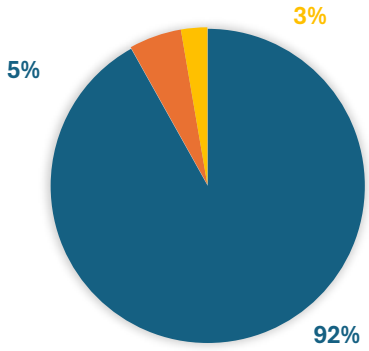


2. You can ask ChemIA to generate a podcast-like text with content from the subject (even in another language) to listen to it later (in your first language). Do you find this tool useful?

Very useful (33)

Moderately useful (2)

Not useful at all (1)

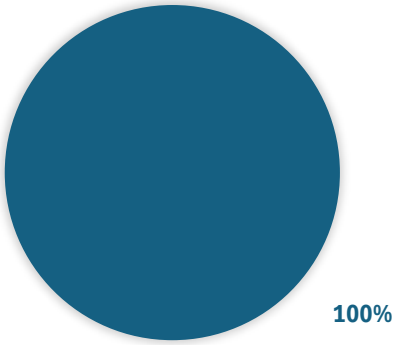


3. ChemIA includes course materials in different languages. You can ask questions in your first language, and the response will be in your first language, based on those articles. Do you find this tool useful?

Very useful (36)

Moderately useful (0)

Not useful at all, I prefer to read articles in their original language. (0)

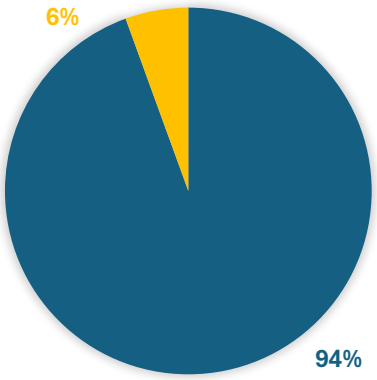


4. ChemIA has been configured to answer questions related to Medicinal Chemistry based on the course content. Do you find useful to have this tool to help answer your questions at any time?

Very useful (34)

Moderately useful (0)

Not useful at all, I prefer to wait for in-person consultations with the professors (2)

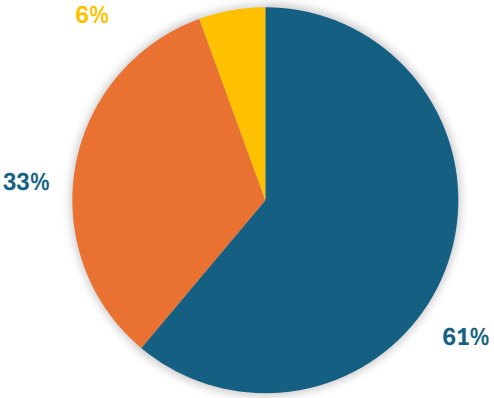


5. What was your opinion about ChatGPT before knowing ChemIA?

I was skeptical (22)

I trusted all its information (12)

I didn’t have a formed opinion (2)

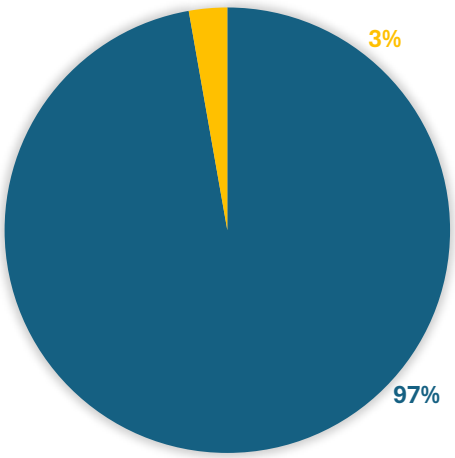


6. If professors from other subjects create a bot with specific information (related to that subject), do you think it could be useful?

I don’t know (1)

Yes, very useful (35)

No, not at all (0)



7. What would you improve in ChemIA? Do you have any suggestions? (optional)

I think the bot is quite complete at this time

As it's relatively new and I have only recently started using it, I don't have any suggestions

I couldn't make any suggestions

None

No

It should provide bibliographies and be accessible without internet

I have no suggestions

I think it's a good tool to reinforce content that may not have been clear in class, even for studying

I find it useful for studying

No suggestions

No, I don't have any suggestions for improving ChemIA as I find its functionality appropriate and I get the answers I need

I wouldn't add any suggestions

I would like it to be available for all subjects, such as Analytical Chemistry or Biological Chemistry

I personally use ChatPDF, it would be great if it had similar features 😊

I have none

I find it very useful

No

I would like to have a tool like this for other subjects

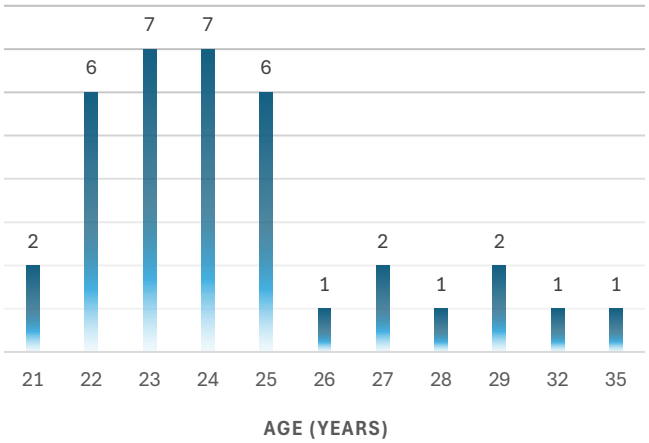
Content updates would be good, as well as better topic association

I would like it to include illustrations

It would be nice to add key questions after some topics so that, once all the information is provided, there is a summary that highlights where to focus.

I have no suggestions

Lastly, to close the statistical analysis: How old are you?



A second survey was carried out to study the use of ChemIA compared with non-Custom ChatGPT. The results are presented below:

1. Did you use ChatGPT or a similar LLM as a study aid?

100% of the survey participants answered "yes."

2. On a scale from 1 to 5, how much do you trust the answers provided by ChatGPT or the LLM you use? A score of 1 represents the lowest level of trust.

The obtained mean was 3.39.

3. For which tasks do you usually use the LLM (such as ChatGPT)?

Students who completed the survey reported mainly use LLMs such as ChatGPT for academic tasks related to their courses. The most frequent uses include drafting and improving written assignments, consulting supplementary information, and preparing study guides. Several students also mentioned translation, bibliographic searches, and generating review questionnaires to reinforce exam preparation. In addition, the tool is often employed to request explanations of specific topics or content they find difficult, helping them check their own understanding and strengthen their learning process.

4. What did you use ChemIA for?

Students reported using ChemIA mainly as a study support tool for the Medicinal Chemistry course. The most frequent uses included consulting specific questions from the subject, clarifying concepts, reviewing material for exams and colloquia, and creating study questionnaires or summaries. Several students highlighted its role in explaining mechanisms or topics they found difficult, supplementing class content, and assisting with assignments or classroom tasks. A few noted that they only tested the platform briefly, while others considered it a useful backup resource for studying.

5. Regarding the questions you asked, in what format did you request the answers?

Most students indicated that they requested ChemIA's responses in text format, highlighting this as the preferred way to interact with the tool. A smaller number mentioned asking for answers in the form of tables or bullet-point items. In one case, a student reported uploading class presentation slides to convert them into continuous text, as this made studying the material easier.

6. Did you use ChemIA to study? How many times?

The responses show a diverse use of ChemIA for studying. While several students reported never using it, many others indicated frequent use ("many times"). A smaller group mentioned specific counts ranging from one to three times. Overall, the answers suggest that, although ChemIA was not adopted by all students, a considerable proportion used it repeatedly as a study aid.

7. Regarding your interaction with ChemIA: How many instructions or prompts did you usually use before finding a satisfactory answer?

Most students reported needing between one and three prompts to obtain a satisfactory answer from ChemIA.

8. On a scale from 1 to 5, how much do you trust the answers provided by ChemIA? A score of 1 represents the lowest level of trust.

The obtained mean was 4.05.

9. What would you improve in ChemIA? Do you have any suggestions?

Students' suggestions for improving ChemIA focused mainly on expanding and refining its resources. Several proposed broadening the knowledge base with more textbooks, papers, and teacher-reviewed material, while also ensuring that answers remain restricted to the provided content. Others emphasised the importance of incorporating or improving images, especially for chemical structures, and generating graphics when requested.

Case-study activity

To explore the classroom use of the developed custom GPT, a pharmacological case-study activity was carried out. During the anti-ulcer drugs lesson, a set of questions was presented to students divided into three groups: those using a generic (non-custom) GPT model, those using ChemIA, and those using traditional resources (lecture notes only).

The case-study statement was: "Marcos frequently experiences heartburn after meals. At home, he has antacids, famotidine, and omeprazole. Which would be the most appropriate option? (This is a hypothetical case for educational purposes. Pharmacists are not authorized to provide this type of medical advice to patients.)" Each group had to answer a set of questions related to anti-ulcer drugs and their mechanisms of action, and then propose the best option for the simulated patient. Afterwards, the entire class shared and discussed their conclusions. Finally, the following set of questions was provided to the students:

Case-study activity Question 1:

Do you trust the obtained information?

Case-study activity Question Answer 1:

All students in the 'ChemIA' and 'Traditional resources (lecture notes only)' groups expressed trust in the information obtained through their assigned method. In contrast, all students in the 'generic (non-custom) GPT model' group reported not being fully confident in the information they get.

Case-study activity Question 2:

Do you think AI can be used to think better, or only to get quick answers?

Case-study activity Question Answer 2:

Most students agreed that artificial intelligence can be useful both for obtaining quick answers and for supporting reasoning processes. Many emphasised that AI should be used as a complementary tool rather than a replacement for critical thinking, highlighting the need to verify the information it provides. While several participants valued its ability to deliver rapid responses, others noted that, when used thoughtfully, it can also help generate new questions, elaborate on concepts, and enhance learning.

Case-study activity Question 3:

In groups "ChemIA" and "generic (non-custom) AI":

Rate how clear the explanation of the mechanism of action was

Case-study activity Question Answer 3:

A total of 88% of students described ChemIA's explanations as very clear, whereas only 62% did so for the non-custom ChatGPT.

Case-study activity Question 4:

If you had the opportunity to redo the assignment, which of the following options would you choose?

Case-study activity Question Answer 4:

58% selected ChemIA, 38% chose traditional class materials, and 4% mentioned ChatGPT. These results indicate a preference for ChemIA over general-purpose AI tools, suggesting that students perceived the custom GPT as a useful academic support tool.

Implementation Details

One of the activities related to the use of ChemIA involved asking it to develop a podcast for the introduction to the topic of nonsteroidal anti-inflammatory drugs (NSAIDs). The prompt used and the generated output are shown below. Although the activity was conducted in Spanish, a translation is provided.

Prompt: Please create a 2-minute podcast introduction on nonsteroidal anti-inflammatory drugs (NSAIDs). The podcast should cover the basic concepts, mechanisms of action, and common uses of NSAIDs. It should be clear, engaging, and suitable for an audience with a basic understanding of medicinal chemistry.

Welcome to today's episode of our medicinal chemistry podcast! In this session, we're diving into the world of Non-Steroidal Anti-Inflammatory Drugs, or NSAIDs, a class of medications many of us have encountered at some point—whether it's for headaches, muscle pain, or inflammation.

But what exactly are NSAIDs, and how do they work? In simple terms, NSAIDs help reduce inflammation, relieve pain, and bring down fever. Popular drugs like ibuprofen, aspirin, and naproxen all belong to this group. Their mechanism of action centers around blocking enzymes known as cyclooxygenases, COX-1 and COX-2. These enzymes are responsible for producing molecules called prostaglandins, which play a major role in causing inflammation and pain in the body. By inhibiting these enzymes, NSAIDs reduce the production of prostaglandins, leading to less inflammation and pain relief.

Now, NSAIDs are used for a wide range of conditions—from managing arthritis and menstrual cramps to treating minor injuries and post-surgical pain. However, they're not without side effects. Since COX-1 also helps protect the stomach lining, long-term use of NSAIDs can increase the risk of gastrointestinal issues, like ulcers.

In short, NSAIDs are incredibly valuable for managing pain and inflammation, but like all drugs, they need to be used wisely. Stay with us as we explore these drugs further and break down their impact on the body!"

Syllabus of the course

-** Thematic Unit 1: Basic concepts of medicinal and pharmaceutical chemistry; physicochemical properties and pharmacological activity. Nomenclature and evolution of drug search methods. Design and chemical structure of drugs, and their influence on absorption, distribution, metabolism and elimination.

- **Thematic Unit 2: Drug-receptor interactions and biological targets. Concepts of drug, activity and potency. Structure-activity relationship and mechanisms of interaction with biological targets (lipids, proteins, nucleic acids). Agonists and antagonists.

- **Thematic Unit 3: Antibacterial agents: disinfectants, antiseptics and antibiotics. Classification by chemical structure and mechanism of action. Inhibitors of cell wall biosynthesis, protein synthesis, nucleic acids and membrane stability.

- **Thematic Unit 4: Antimycobacterials: structure and resistance of mycobacteria. Drugs for tuberculosis and leprosy, and their mechanisms of action.

- **Thematic Unit 5: Antivirals: general concepts, mechanisms of action and classification according to the type of virus. Combined therapies and resistance.

- **Thematic Unit 6: Antifungals: types of mycoses and mechanisms of action. Classification according to their effect on plasma membrane, cell wall and nucleic acids.

-** Thematic Unit 7: Antiprotozoals: protozoal diseases such as malaria and Chagas disease. Mechanisms of action of antiprotozoal agents.

- **Thematic Unit 8: Anthelmintics: diseases caused by cestodes and nematodes. Mechanism of action and advantages of avermectins such as ivermectin.

- **Thematic Unit 9: Antineoplastics: classification according to the mechanism of action. Agents acting on DNA, mitosis and extracellular factors, and those affecting the immune system.

- **Thematic Unit 10: Steroidal anti-inflammatory drugs: structure, nomenclature and mechanisms of action of steroid hormones. Steroids in pharmacology and their chemical modifications.

- **Thematic Unit 11: Non-steroidal anti-inflammatory drugs (NSAIDs): arachidonic acid metabolites, mechanisms of action and structural classification. Cyclooxygenase inhibitors.

- **Thematic Unit 12: Antilipidemics: lipoprotein biochemistry and classification of hyperlipidemias. Treatment with statins and fibrates.

- **Thematic Unit 13: Anti-allergic and anti-ulcer drugs: histamine and H1, H2, H3 receptors. Antihistamines and anti-ulcer agents, including proton pump inhibitors.

Accuracy and consistency test

The set of questions given for the accuracy and consistency test are displayed below:

- Question 1

A) What structural particularity do steroid hormones present?

B) Name 5 steroid molecules that can be biosynthesised naturally from squalene (name the molecules).

- Question 2

A) What is the therapeutic use of the histamine molecule?

B) What is the therapeutic use of H1 receptor antagonists?

C) Name three families of H1 receptor antagonists.

- Question 3

A) Describe the importance of selective COX-2 inhibition over COX-1.

B) Name examples from the salicylate family within NSAIDs. Name one example of an irreversible inhibitor and justify the reason for this inhibition.

- Question 4

Disease-causing agents can be: non-cellular, eukaryotic cells, or prokaryotic cells.

Based on this, classify the following agents:

A) Bacteria

B) Fungi

C) Viruses

D) Helminths

- Question 5

A) Name the five main mechanisms of action of antifungal agents.

B) Regarding compounds involved in the function of the plasma membrane: azoles inhibit the synthesis of an essential component of the fungal cell. What is this compound?

- Question 6

A) What is the main therapeutic function of the commonly called H1 antihistamines?

B) What is the main therapeutic function of the commonly called H2 antihistamines?

C) Regarding anti-ulcer agents: briefly explain three different mechanisms of action of anti-ulcer agents and cite one example for each.

- Question 7

A) Name the differences between the processes of competitive and non-competitive inhibition.

B) A membrane receptor activates a biological function when it binds to the endogenous ligand X. The active ingredient Z is a pure agonist of X. What will happen to the biological response in the presence of Z? Justify your answer.

- Question 8

What is the mechanism of action of statins?

- Question 9

Angiotensin-converting enzyme inhibitors are drugs used, among other functions, for the treatment of arterial hypertension.

A) Describe the basic mechanism of action of these drugs.

B) In the following figure, the chemical structure of captopril is shown. What is the role of the mercapto group in the structure-activity relationship of this family of drugs?

- Question 10

A) Regarding antibacterial agents that inhibit tetrahydrofolic acid synthesis, which enzymes are commonly inhibited by the most widely used drugs?

B) Name the most commonly used drugs and the name of the medicinal combination that includes two of them.

- Question 11

What main characteristics make beta-lactam antibiotics widely used?

- Question 12

What pharmacological actions are characteristic of NSAID? What is its mechanism of action?

- Question 13

A) Name the therapeutic group to which the drug chloroquine belongs. For what type of disease was this active ingredient widely used?

B) Explain its mechanism of action.

- Question 14

What modification is usually made to natural estrogens to make them suitable for oral administration?

- Question 15

A) What is the therapeutic use of H2 receptor antagonists?

B) What differences and similarities can you mention between the mechanism of action of ranitidine compared to that of the proton pump inhibitors (prazoles)? Explain.

Student-ChemIA interaction

The interaction between a student and ChemIA after the antiviral class was recorded. It is worth noting that the conversation was carried out in Spanish.

Student question #1:

Hi!

ChemIA Answer #1:

Hello! 😊

How can I help you today with Medicinal Chemistry or UCSF Pharmacy Production Policies? I'm ready to solve doubts, explain concepts or give you a hand with the chair's booklets.

Student question #2:

Could you explain to me the mechanism of action of valacyclovir? I don't quite understand it

ChemIA Answer #2:

💊 What is Valacyclovir?

Valacyclovir is a prodrug of acyclovir. That means it’s not active on its own, but once inside the body, it's converted into the active compound, acyclovir, by an enzyme called valacyclovirase, mainly in the intestines and liver.

Valacyclovir has better oral bioavailability than acyclovir, which is why it’s commonly used.

🦠 What viruses does it target?

Mainly:

●Herpes Simplex Virus (HSV-1 and HSV-2) – causes oral and genital herpes

●Varicella-Zoster Virus (VZV) – causes shingles

🔬 How does it work? (Mechanism of action)

Once valacyclovir is converted into acyclovir, here's how acyclovir acts:

🧬 Step-by-step mechanism:

1.Activation by viral thymidine kinase (TK):

oAcyclovir enters the infected cell.

oThe viral thymidine kinase enzyme (produced only in infected cells) phosphorylates acyclovir into acyclovir monophosphate.

oThis selective activation is key—it means the drug mainly acts in virus-infected cells, reducing harm to healthy cells.

2.Further phosphorylation by host enzymes:

oHuman (host) enzymes convert acyclovir monophosphate into acyclovir triphosphate, the active form.

3.Inhibition of viral DNA polymerase:

oAcyclovir triphosphate mimics a nucleotide and competes with the natural ones to get incorporated into viral DNA.

oOnce incorporated, it terminates the DNA chain because it lacks a 3'-OH group required to add the next nucleotide.

oThis blocks viral DNA replication, effectively stopping the virus from multiplying.

🎯 Why is it selective?

Because only infected cells express the viral thymidine kinase needed to activate the drug. So acyclovir remains inactive in healthy cells—that's why it's so safe and selective.

📝 Quick Summary:

●Valacyclovir → converted to acyclovir in the body.

●Acyclovir → activated in infected cells by viral thymidine kinase.

●Acyclovir triphosphate → incorporated into viral DNA → chain termination.

●End result: stops the virus from replicating 🛑 🧬

Let me know if you'd like a diagram or a comparison with other antivirals like ganciclovir or zidovudine!

Student question #3:

What´s the difference between valaciclovir and aciclovir?

ChemIA Answer #3:

Great question! Let's break down the difference between valacyclovir and acyclovir in a simple and practical way:

🔁 Relationship:

●Valacyclovir is the prodrug of acyclovir.

●This means valacyclovir is converted into acyclovir inside the body (by enzymes in the gut and liver).

💊 In Practice:

●Valacyclovir is often preferred for oral use because you don't need to take it as often—it's easier for patients to stick to the treatment.

●Acyclovir is used when a topical or intravenous form is needed, or when cost is a major factor (acyclovir is usually cheaper).

🧠 Quick Analogy:

Think of valacyclovir as a more efficient delivery system for acyclovir. Once inside your body, it turns into the same weapon (acyclovir), just with less effort and better absorption.

Let me know if you'd like help comparing it with other antivirals or need help remembering this difference for exams!