

Report: Role-based vs Chain-of-Thought Prompting — Photosynthesis Example

Objective

Compare two prompting styles — Role-based (audience-driven) and Chain-of-Thought (step-by-step reasoning) using the task 'Explain how photosynthesis works.'

Experiment Setup

Model: TinyLlama/TinyLlama-1.1B-Chat-v1.0
Tokenizer: AutoTokenizer with chat template
Role-based run: max_new_tokens=276
Chain-of-thought run: max_new_tokens=1076
Sampling params: do_sample=True, temperature=0.8, top_p=0.9, repetition_penalty=1.2

Prompts Tested

Role-based: 'You are a high school biology teacher. Explain photosynthesis to students in simple words.'
Chain-of-Thought: 'Explain photosynthesis step by step, reasoning each step clearly.'

Outputs Summary

Role-based: Short, clear, student-friendly explanation (~150-300 words).
Chain-of-Thought: Longer, detailed, stepwise explanation (~400-1000+ words).

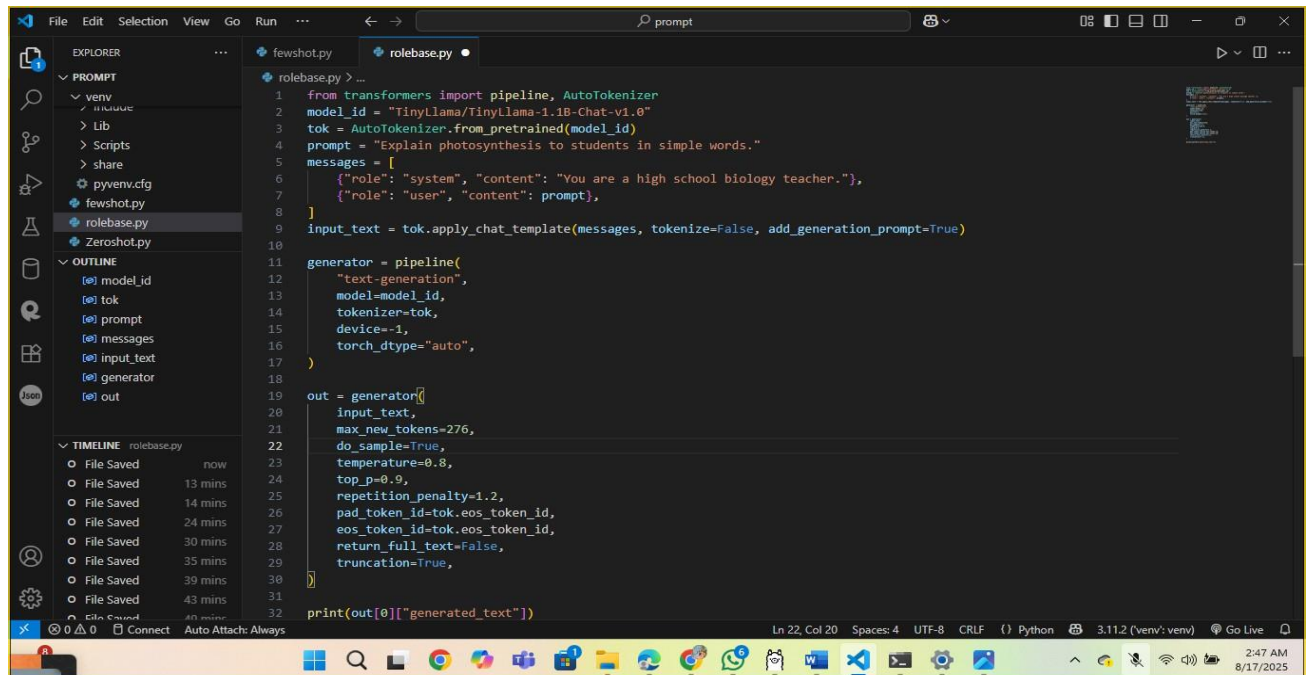
Comparison Table

Aspect	Role-based prompt	Chain-of-thought prompt
Prompt	Explain simply as a teacher	Explain step by step with reasoning
Max tokens	276	1076
Length	Short-medium (~150–300 words)	Long (~400–1000+ words)
Detail	Medium (basic clarity)	High (mechanistic, multi-section)
Tone	Simple, educational	Technical, academic
Best Use	Teaching, summaries	Deep learning, detailed notes

Reflections

Role-based prompting produced a concise, student-friendly explanation, while Chain-of-Thought prompting generated a long, detailed, mechanistic explanation. Audience and token budget matter: Role-based is ideal for teaching, while Chain-of-Thought is useful for technical deep-dives.

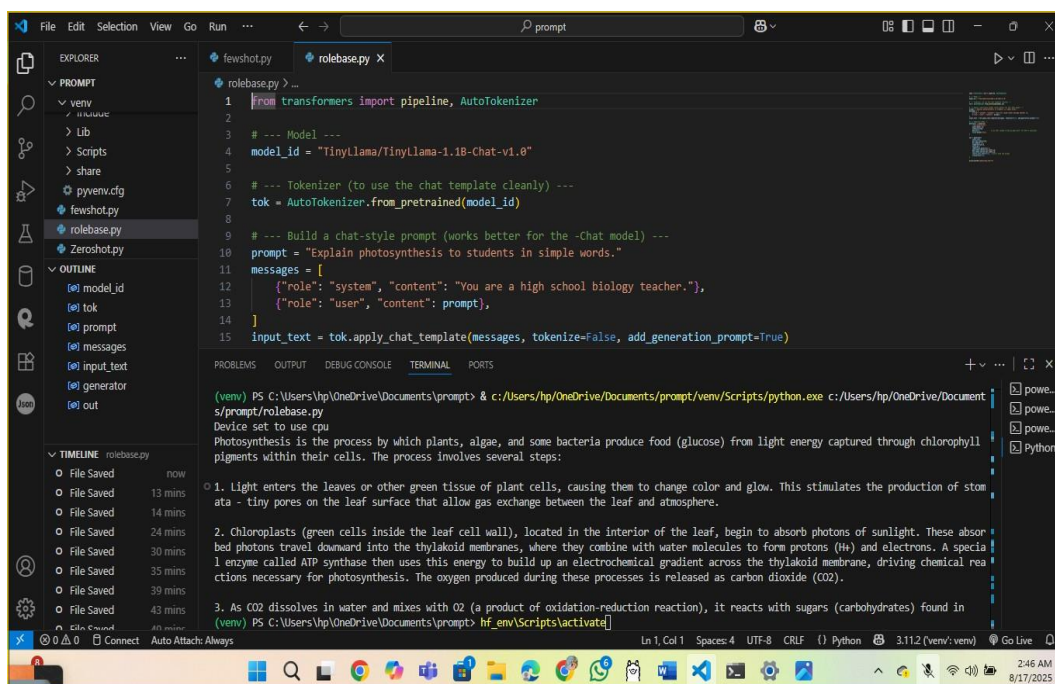
Role-based Prompt — Code Implementation



The screenshot shows a VS Code editor with a file explorer on the left, an outline view, and a main editor window displaying the code for `rolebase.py`. The code uses the `transformers` library to create a chat-style prompt and generate text.

```
1 from transformers import pipeline, AutoTokenizer
2 model_id = "TinyLlama/TinyLlama-1.1B-Chat-v1.0"
3 tok = AutoTokenizer.from_pretrained(model_id)
4 prompt = "Explain photosynthesis to students in simple words."
5 messages = [
6     {"role": "system", "content": "You are a high school biology teacher."},
7     {"role": "user", "content": prompt},
8 ]
9 input_text = tok.apply_chat_template(messages, tokenize=False, add_generation_prompt=True)
10
11 generator = pipeline(
12     "text-generation",
13     model=model_id,
14     tokenizer=tok,
15     device=-1,
16     torch_dtype="auto",
17 )
18
19 out = generator(
20     input_text,
21     max_new_tokens=276,
22     do_sample=True,
23     temperature=0.8,
24     top_p=0.9,
25     repetition_penalty=1.2,
26     pad_token_id=tok.eos_token_id,
27     eos_token_id=tok.eos_token_id,
28     return_full_text=False,
29     truncation=True,
30 )
31
32 print(out[0]["generated_text"])
```

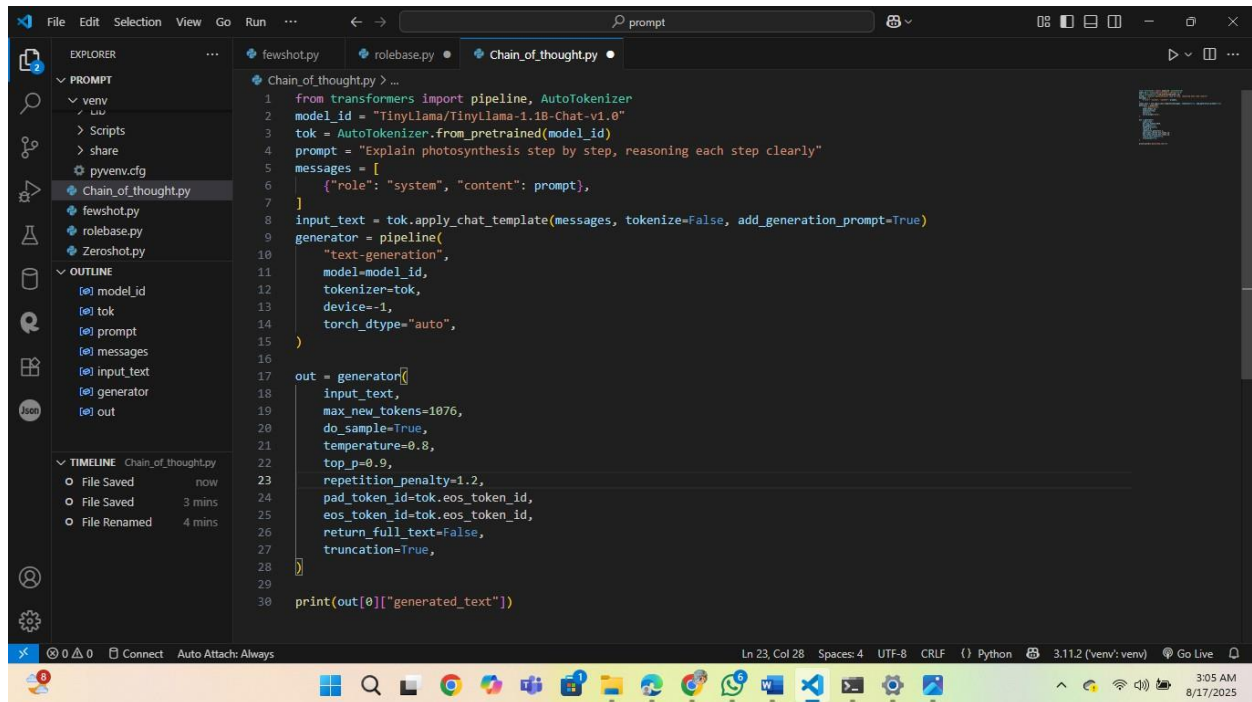
Role-based Prompt — Output Example



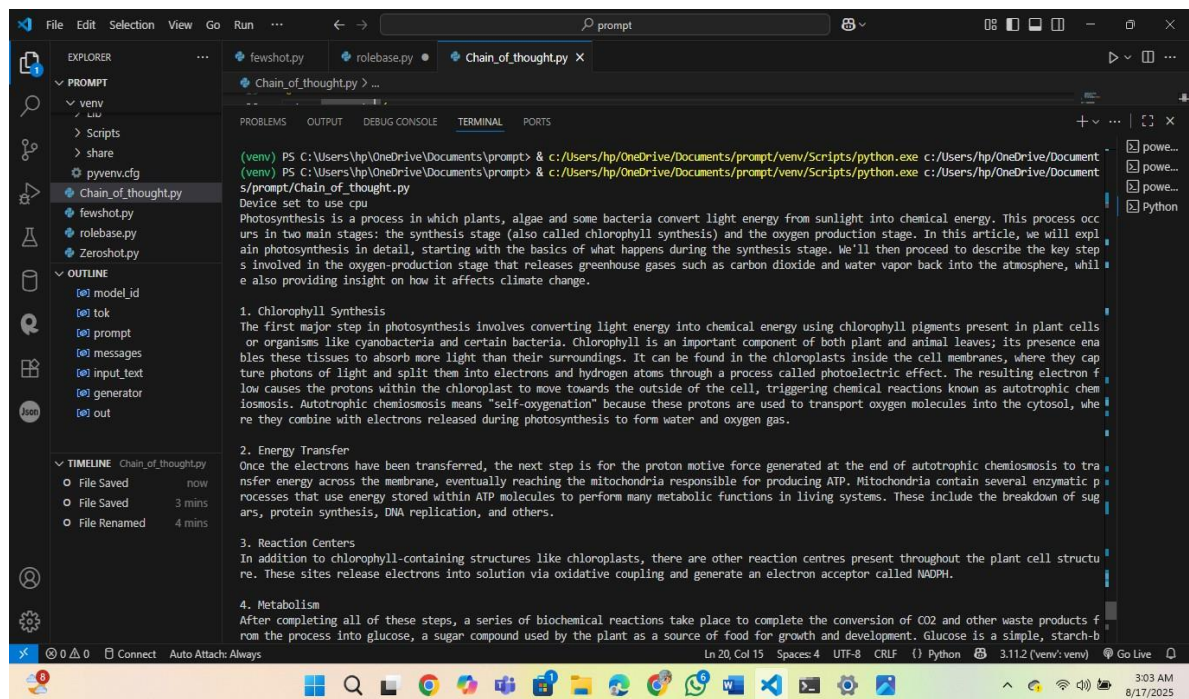
The screenshot shows the same VS Code editor as before, but now the terminal window at the bottom displays the output of the code. The output is a detailed explanation of photosynthesis, generated by the model.

```
(venv) PS C:\Users\hp\OneDrive\Documents\prompt> & c:\Users\hp\OneDrive\Documents\prompt\venv\Scripts\python.exe c:\Users\hp\OneDrive\Documents\prompt\rolebase.py
Device set to use cpu
Photosynthesis is the process by which plants, algae, and some bacteria produce food (glucose) from light energy captured through chlorophyll pigments within their cells. The process involves several steps:
1. Light enters the leaves or other green tissue of plant cells, causing them to change color and glow. This stimulates the production of stomata - tiny pores on the leaf surface that allow gas exchange between the leaf and atmosphere.
2. Chloroplasts (green cells inside the leaf cell wall), located in the interior of the leaf, begin to absorb photons of sunlight. These absorbed photons travel downward into the thylakoid membranes, where they combine with water molecules to form protons (H+) and electrons. A special enzyme called ATP synthase then uses this energy to build up an electrochemical gradient across the thylakoid membrane, driving chemical reactions necessary for photosynthesis. The oxygen produced during these processes is released as carbon dioxide (CO2).
3. As CO2 dissolves in water and mixes with O2 (a product of oxidation-reduction reaction), it reacts with sugars (carbohydrates) found in
```

Chain-of-Thought Prompt — Code Implementation



Chain-of-Thought Prompt — Output (Part 1)



Chain-of-Thought Prompt — Output (Part 2)

ars, protein synthesis, DNA replication, and others.

3. Reaction Centers
In addition to chlorophyll-containing structures like chloroplasts, there are other reaction centres present throughout the plant cell structure. These sites release electrons into solution via oxidative coupling and generate an electron acceptor called NADPH.

4. Metabolism
After completing all of these steps, a series of biochemical reactions take place to complete the conversion of CO₂ and other waste products from the process into glucose, a sugar compound used by the plant as a source of food for growth and development. Glucose is a simple, starch-based carbohydrate, one of the most abundant sources of fuel for our bodies. Some additional complex carbohydrates, proteins, and lipids may also be formed during this phase.

5. Oxygen Production
Finally, the glucose produced becomes part of a larger network of respiratory pathways that ultimately produces oxygen in exchange for nutrients needed for growth. Once the glucose has been converted to ATP through glycolysis and then to pyruvate under the control of the Krebs cycle, it combines with NADH (a type of non-ATP NAD⁺) in the electron transport chain to create NADH + H⁺ + O₂. The oxygen is released into the environment in the form of carbon dioxide and water vapor, which returns the plant cells to the water cycle, thus contributing to the overall feedback loop that helps stabilize global temperatures.

Conclusion
In summary, photosynthesis is a natural process that takes place primarily in plants and algae but can also occur in some bacteria. Through a series of chemical reactions involving chlorophyll and other biological components, plants transform solar energy into food for growth and development. During the synthesis stage, protons are extracted from the cell membrane and moved to the chloroplast. In the oxygen production stage, the remaining oxygen is released into the surrounding environment through an interaction between the electron transport chain and the Krebs cycle. Photosynthesis plays a crucial role in regulating temperature, supporting the life cycles of aquatic organisms, and creating diverse ecosystems globally. Understanding the mechanistic basis behind photosynthesis is vital to optimizing the management of ecological systems and minimizing environmental impacts.

(venv) PS C:\Users\hp\OneDrive\Documents\prompt> Get-ChildItem env: | Out-File "C:\Users\hp\AppData\Local\Temp\tmp-12732n4XvuPHzRyGN.txt"

Ln 20, Col 15 Spaces: 4 UTF-8 CRLF () Python 3.11.2 (venv: venv) Go Live

