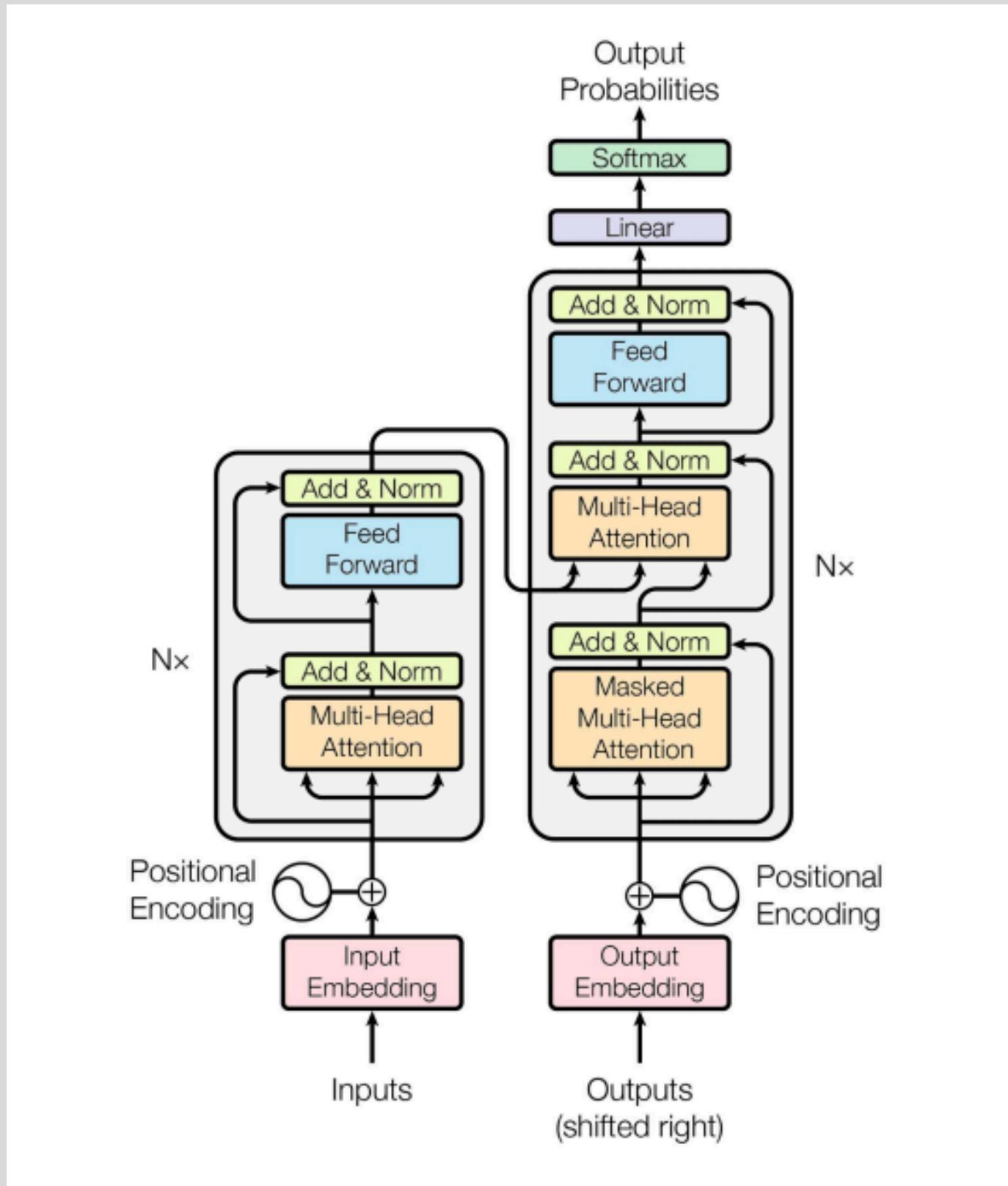


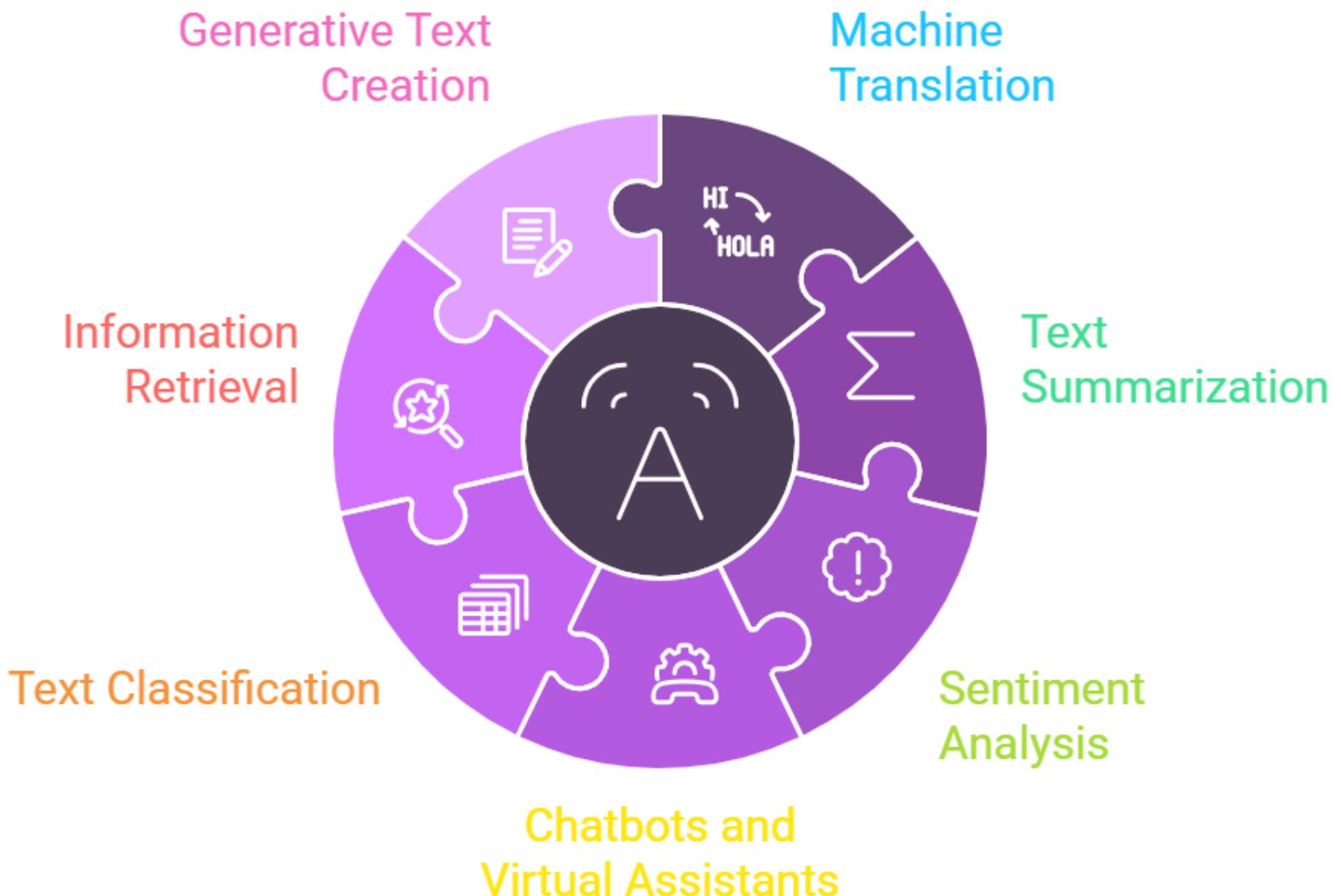
Transformer



معماری ترنسفورمر برای اولین بار در سال ۲۰۱۷ در مقاله‌ای با عنوان مشهور "Attention Is All You Need" معرفی شد.

attention is all you need •

Applications of Transformer Models



Machine Translation • ترجمه ماشینی

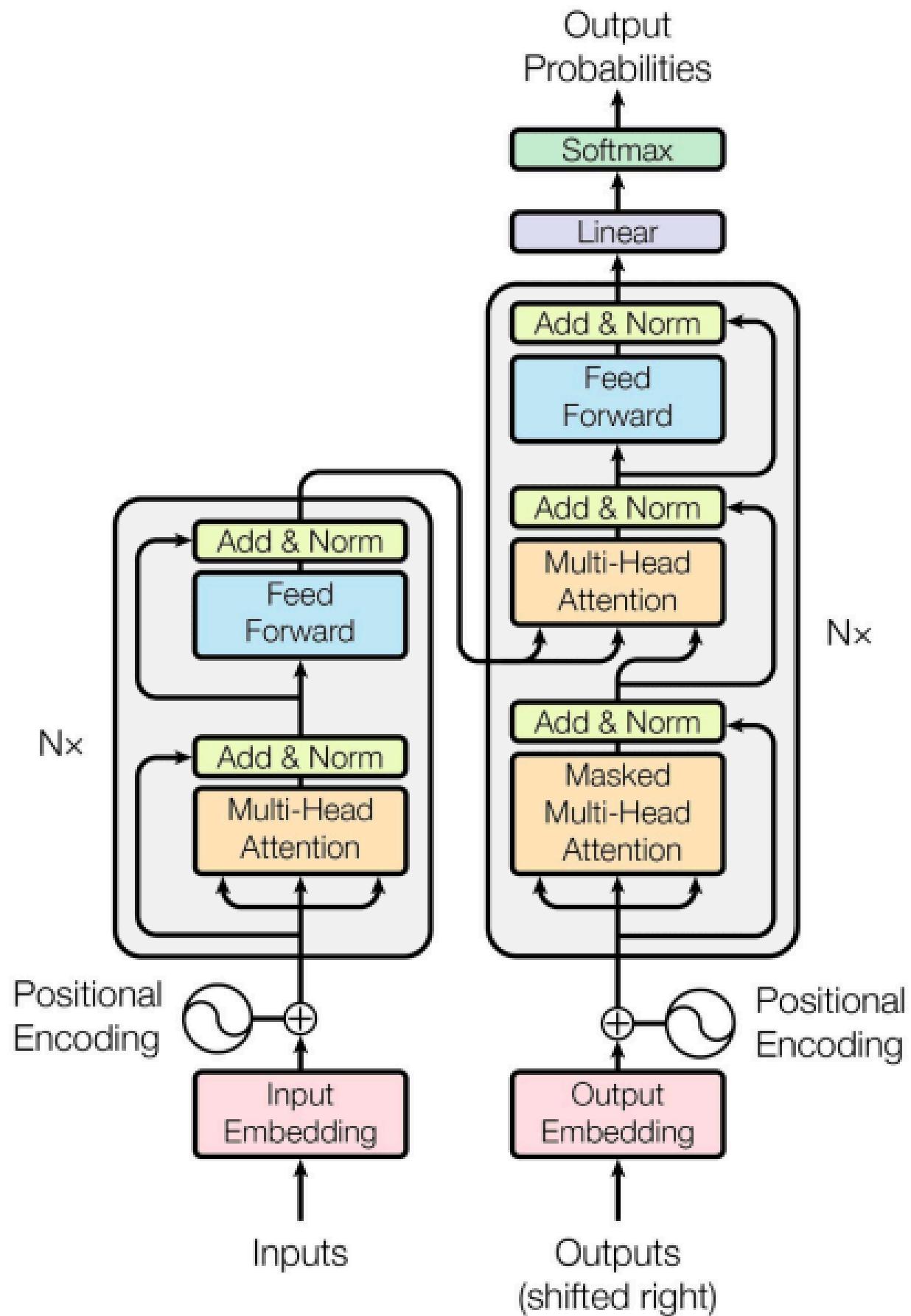
Generative Text Creation • تولید متن مولد

Text Summarization • خلاصه‌سازی متن

Information Retrieval • بازیابی اطلاعات

حوزه کاربرد	مدل‌های بنیادی	محصولات و سیستم‌های شاخص
برداش زبان طبیعی (NLP) و LLM‌ها	BERT, GPT-3/4, T5	چت‌بات و دستیار مجازی، موتورهای جستجوی معنایی ChatGPT, Gemini, LLaMA, Claude
بینای کامپیوتر (Computer Vision)	Vision Transformer (ViT)	DALL-E, Midjourney (تولید تصویر)، سیستم‌های پیشرفته تشخیص تصویر (Image Recognition)
بیوانفورماتیک و پروتئین‌شناسی	معماری‌های ترنسفورمر سفارشی (مانند ESM)	AlphaFold (بیش‌بینی ساختار پروتئین)، مدل‌سازی توالی‌های RNA و DNA
سیستم‌های توصیه‌گر	RecSys Transformers	موتورهای توصیه‌گر پیشرفته (مانند نتفلیکس و اسپاتیفای)

Transformer Architecture



۱. مدل‌های فقط-رمزنگار (Encoder-Only)

- هدف: فهم دوطرفه و نمایش زمینه محور (Bidirectional Understanding).
- مدل‌های شاخص: BERT, ViT (برای تصاویر).
- کاربردها و محصولات:

◦ جستجوی معنایی: Google Search

◦ بینایی کامپیوترا: تشخیص تصویر (Google Photos) و NLP: تحلیل احساسات، توصیه‌گرها.

۲. مدل‌های فقط-رمزنگشا (Decoder-Only)

- هدف: تولید محتواهای یک‌طرفه و خودبازگشتی (Unidirectional Generation).
- مدل‌های شاخص: GPT, LLaMA, Claude.
- کاربردها و محصولات:

◦ چت‌بات‌ها: ChatGPT, Google Gemini

◦ تولید خلاقانه: تولید متن و کد (GitHub Copilot)

◦ تولید تصویر: DALL-E, Midjourney

۳. مدل‌های رمزنگار-رمزنگشا (Encoder-Decoder)

- هدف: تبدیل توالی به توالی (Sequence-to-Sequence).
- مدل‌های شاخص: T5, BART.
- کاربردها و محصولات:

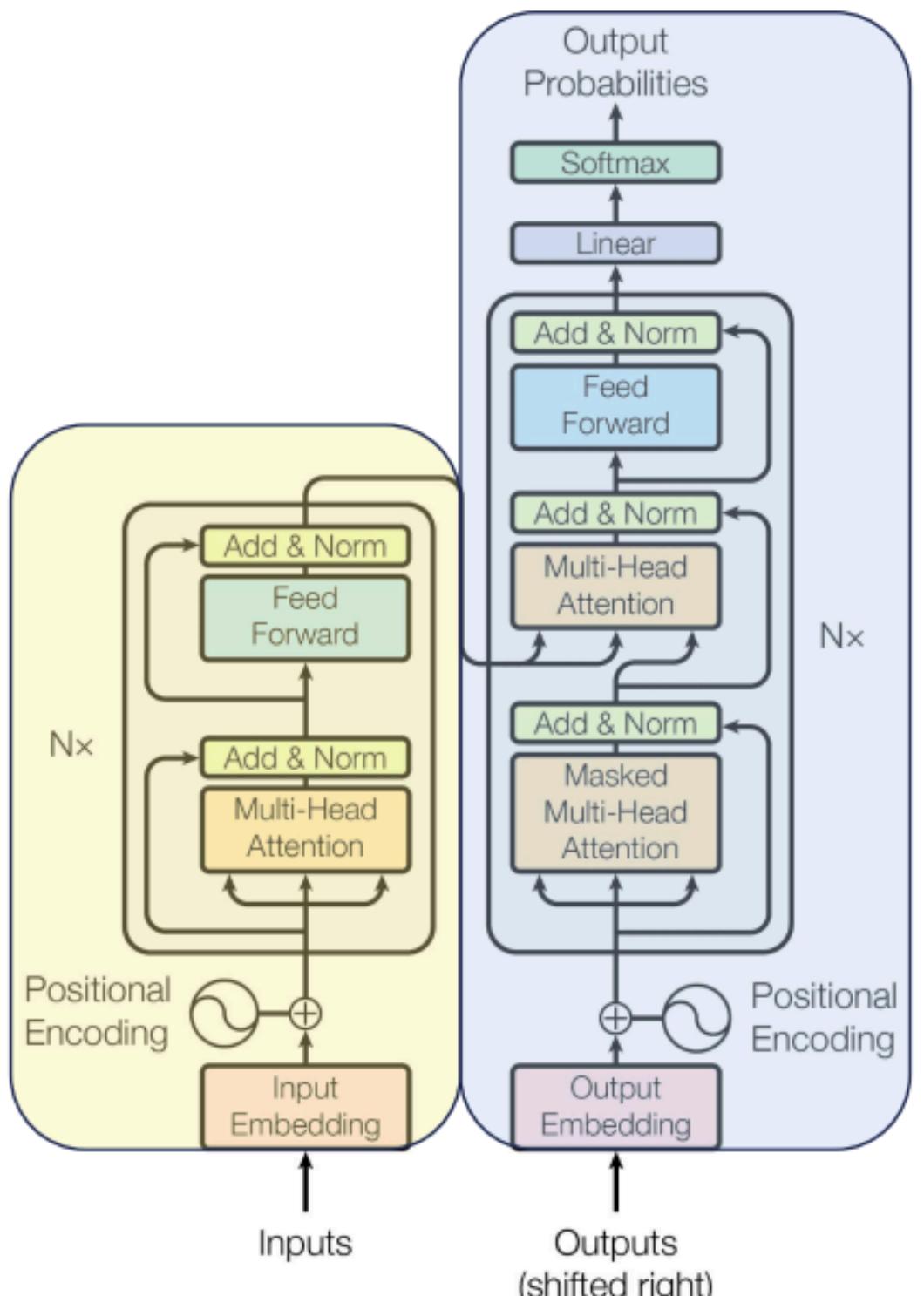
◦ ترجمه ماشینی: Google Translate

◦ خلاصه‌سازی متن.

◦ بیوانفورماتیک: AlphaFold (پیش‌بینی ساختار پروتئین).

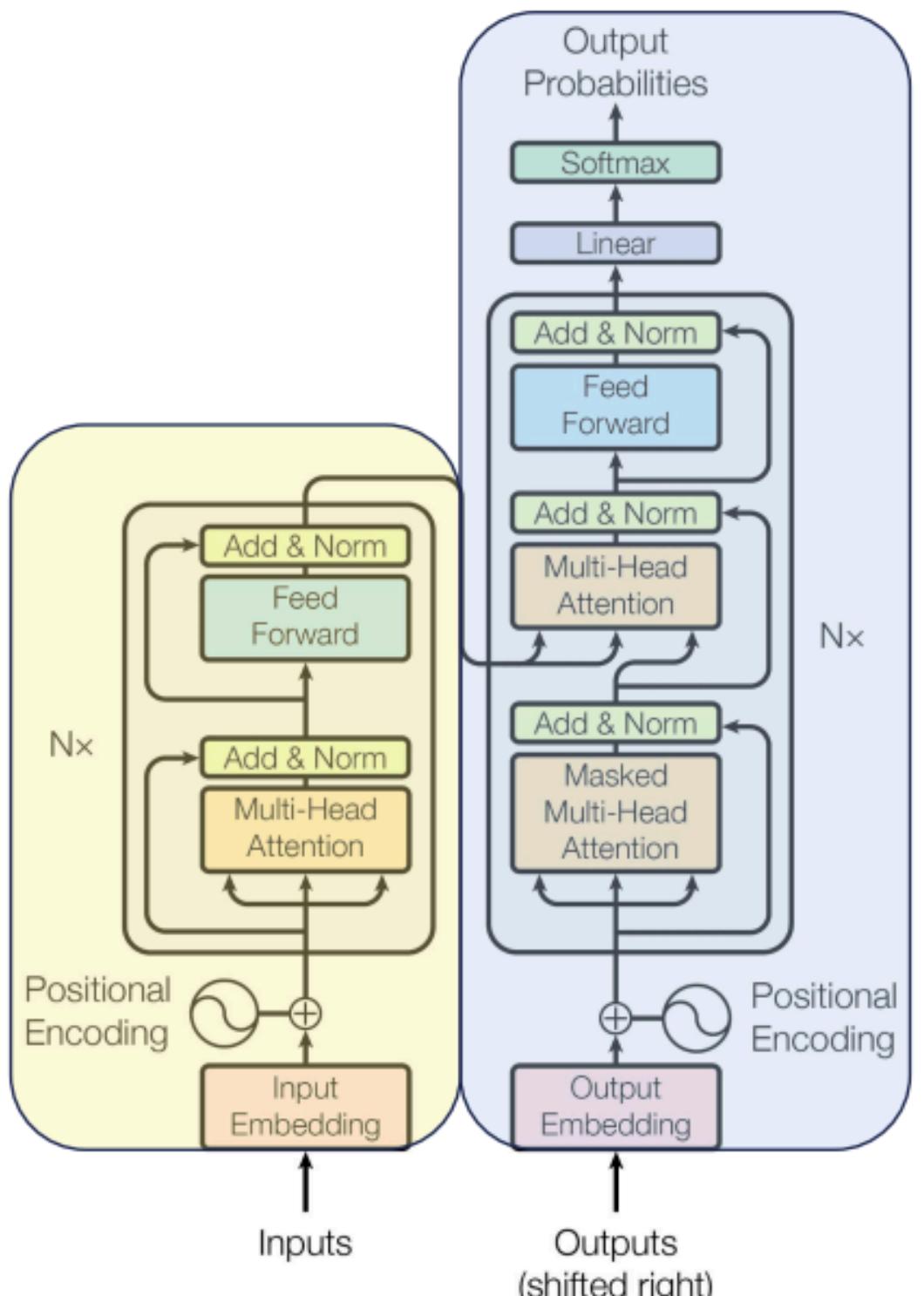
BERT
Oct 2018

Representation



GPT
June 2018

Generation



the →

the fluffy →

the fluffy blue →

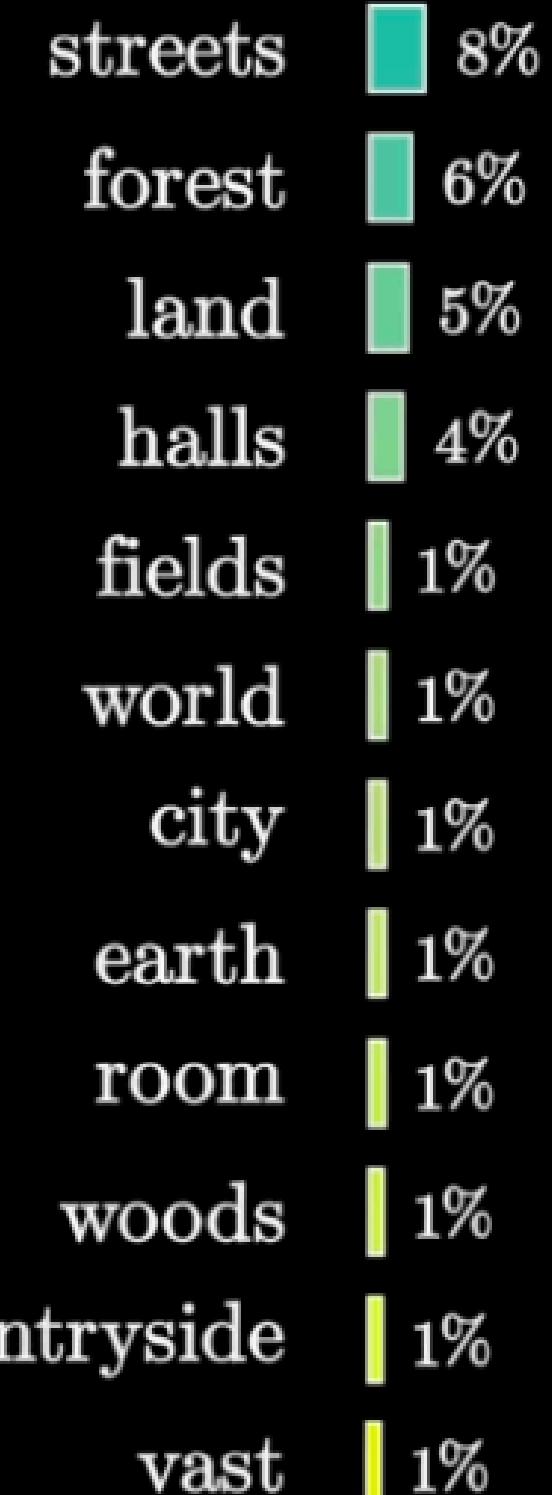
the fluffy blue creature →

the fluffy blue creature roamed →

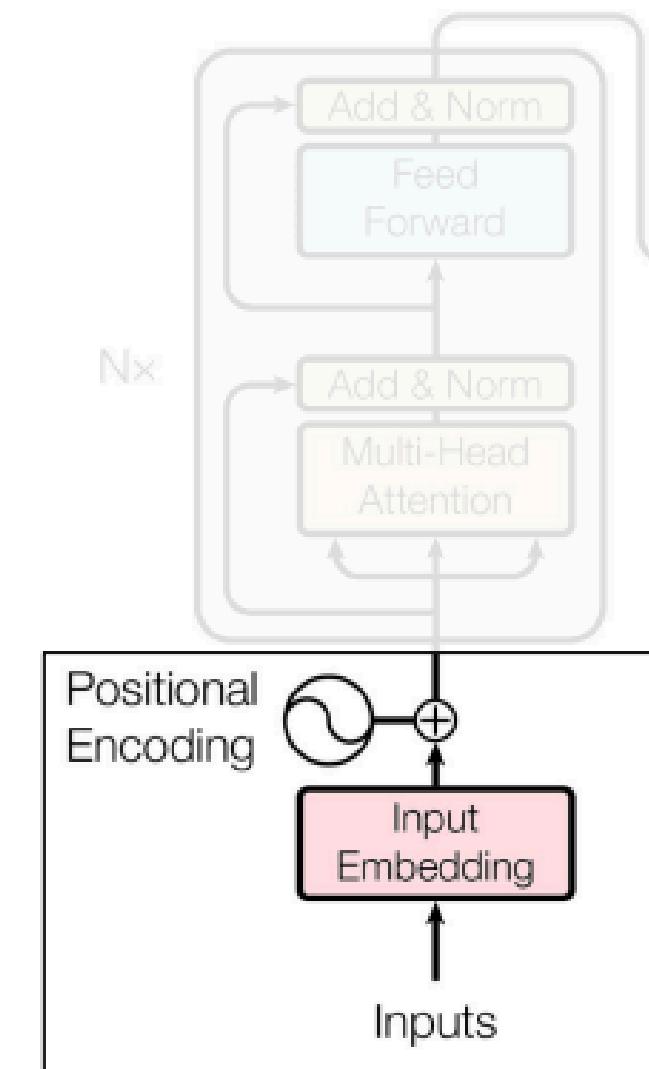
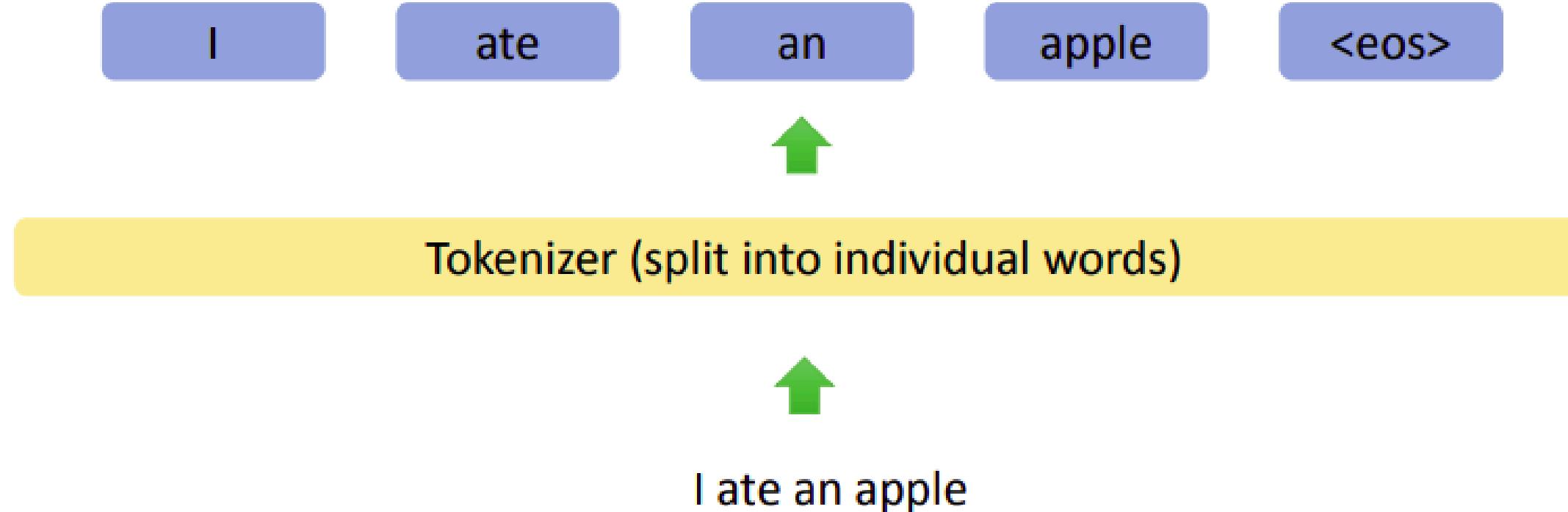
the fluffy blue creature roamed the →

the fluffy blue creature roamed the verdant →

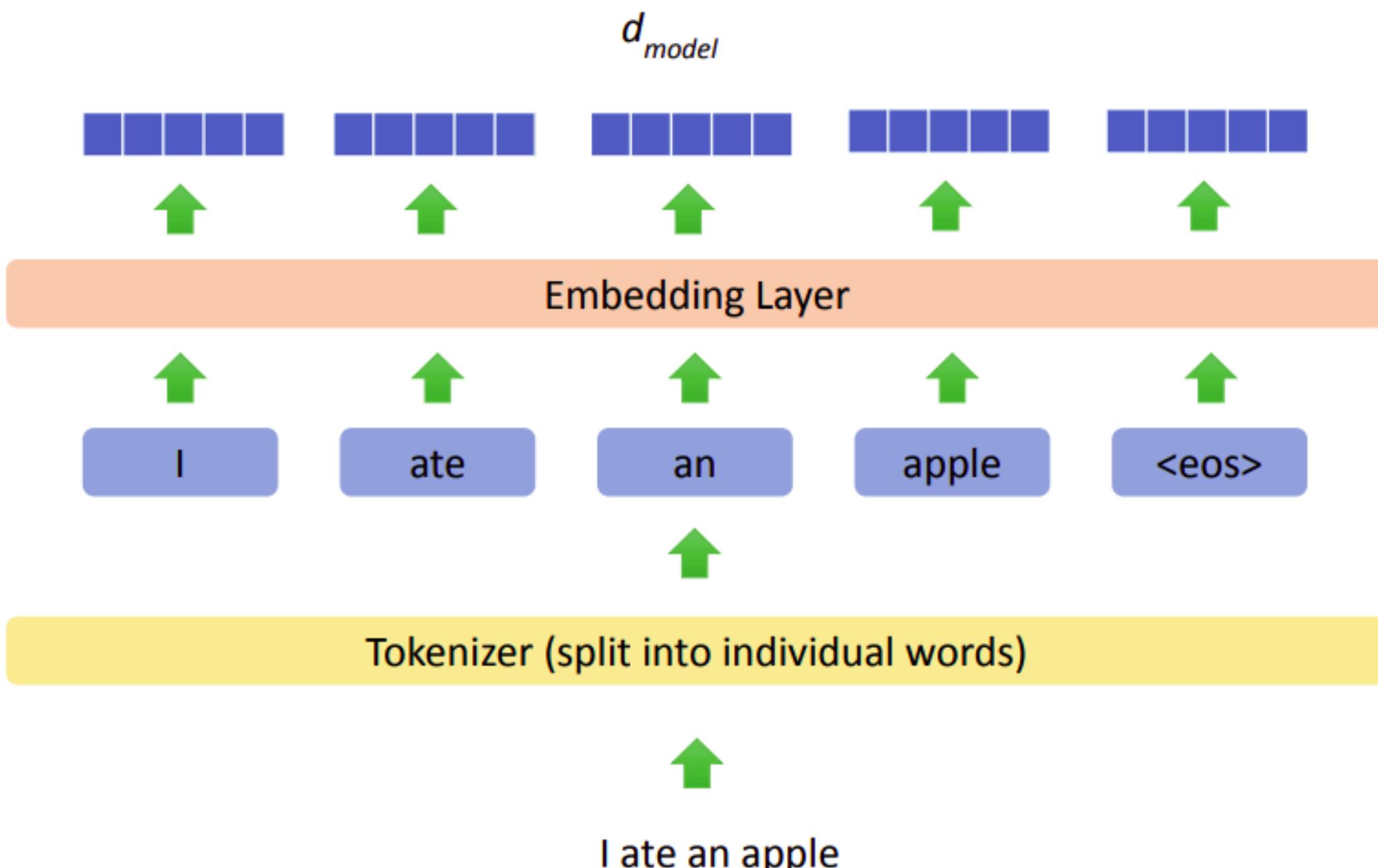
the fluffy blue creature roamed the verdant forest →



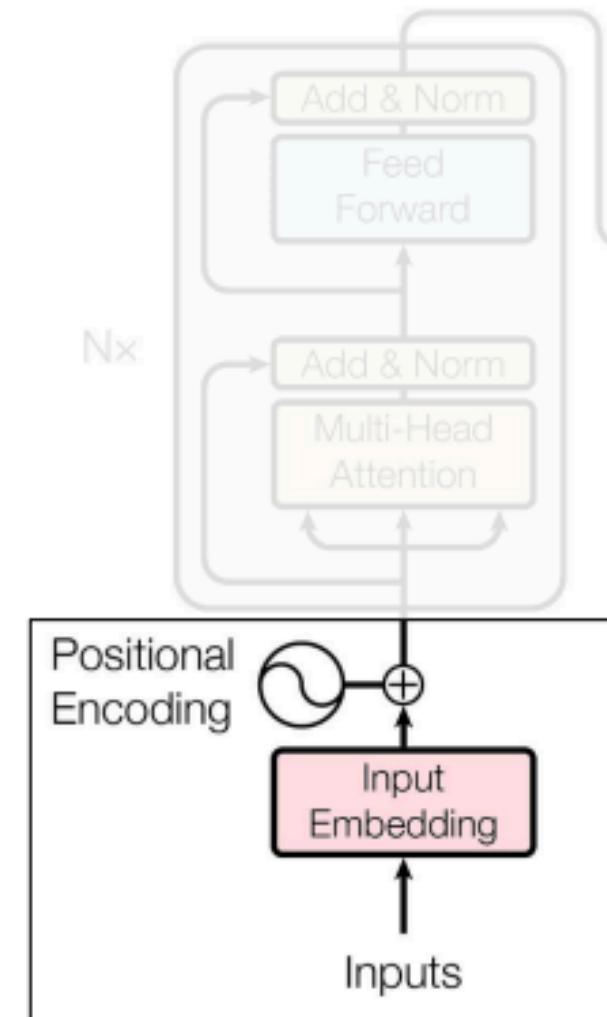
Tokenization



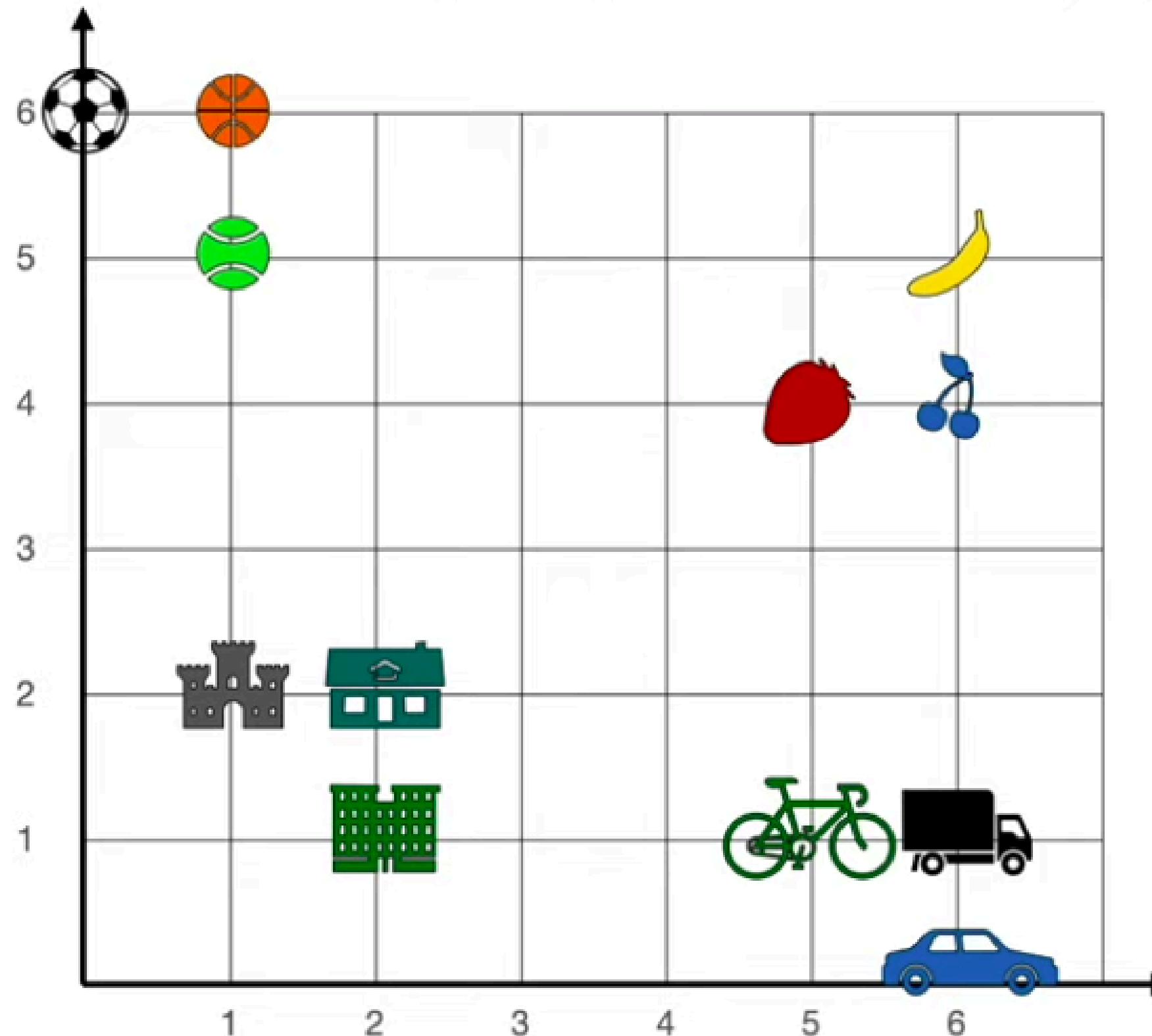
Input Embeddings



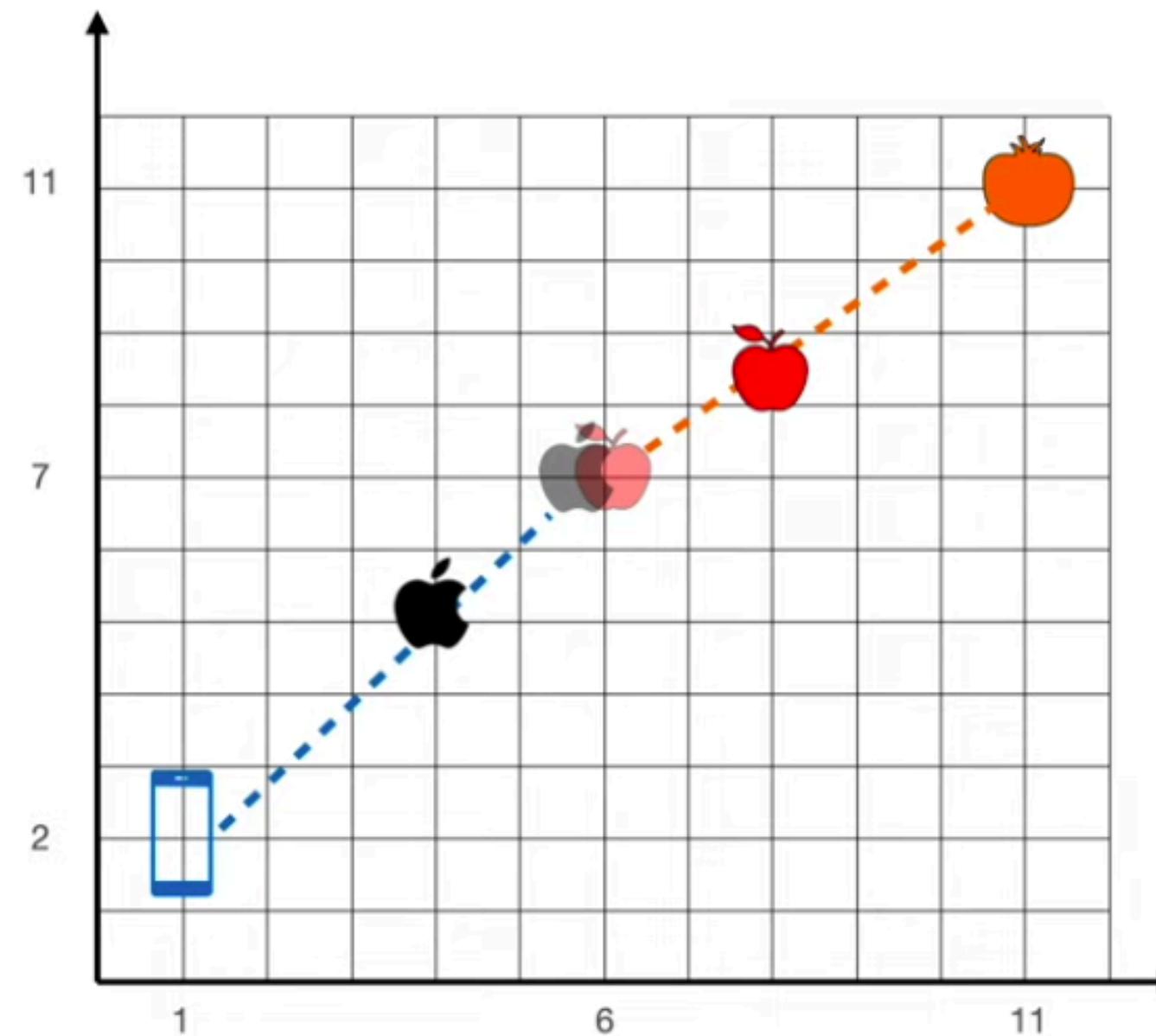
Generate Input Embeddings



Where would you put the word apple?

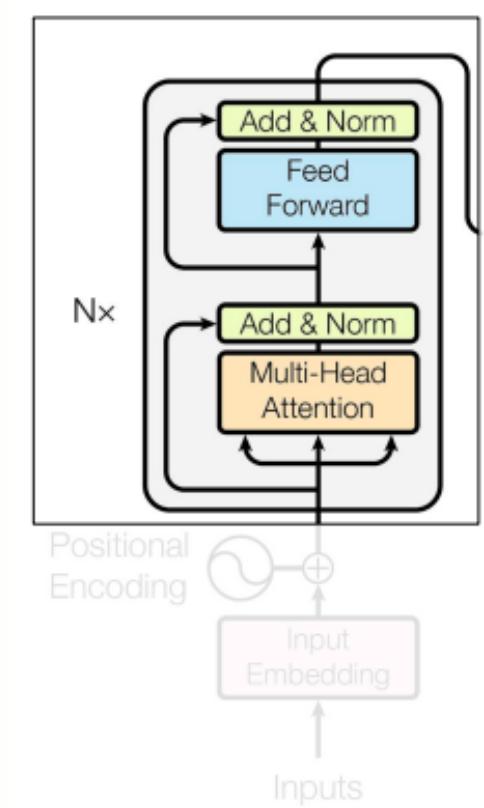
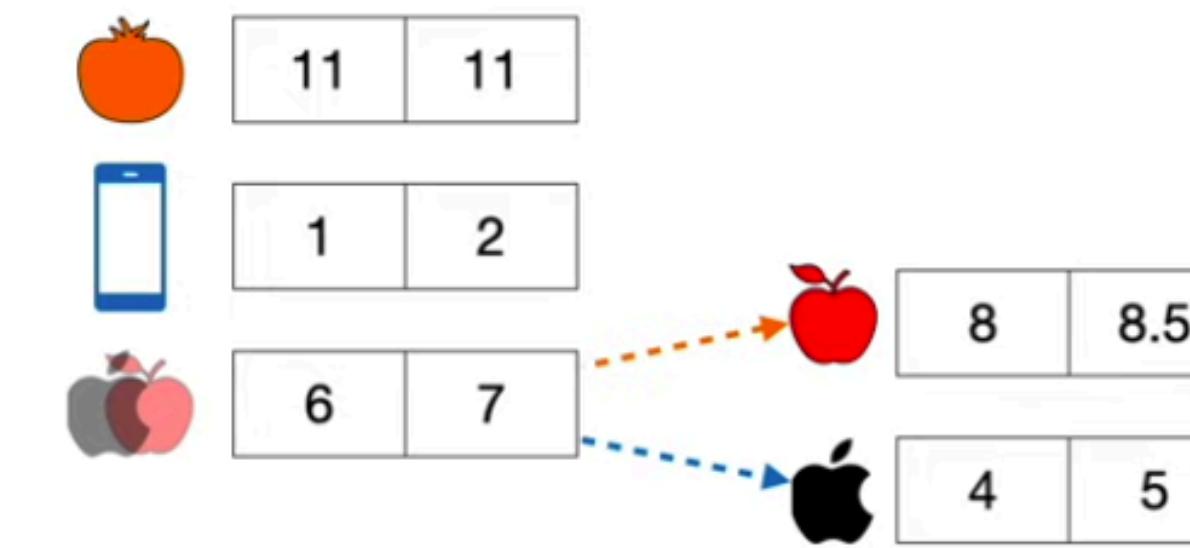


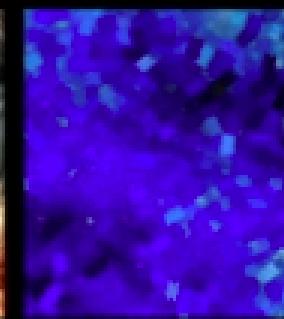
Attention



please buy an **apple** and an **orange**

apple unveiled the new **phone**





a fluffy blue creature roamed the verdant forest

1

2

3

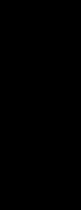
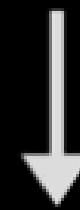
4

5

6

7

8



12,288

$$\left\{ \begin{matrix} \begin{bmatrix} 6.0 \\ 0.2 \\ 3.0 \\ 6.5 \\ 2.9 \\ 6.1 \\ 4.2 \\ 1.3 \\ \vdots \\ 3.0 \end{bmatrix} & \begin{bmatrix} 5.6 \\ 5.8 \\ 5.7 \\ 6.5 \\ 6.5 \\ 4.3 \\ 8.9 \\ 3.6 \\ \vdots \\ 4.3 \end{bmatrix} & \begin{bmatrix} 8.8 \\ 8.0 \\ 7.0 \\ 1.0 \\ 9.1 \\ 7.1 \\ 9.9 \\ 1.5 \\ \vdots \\ 8.6 \end{bmatrix} & \begin{bmatrix} 1.6 \\ 6.1 \\ 1.2 \\ 8.4 \\ 8.0 \\ 5.6 \\ 4.0 \\ 0.7 \\ \vdots \\ 6.9 \end{bmatrix} & \begin{bmatrix} 4.5 \\ 7.1 \\ 8.6 \\ 9.7 \\ 8.5 \\ 0.1 \\ 3.6 \\ 7.2 \\ \vdots \\ 1.7 \end{bmatrix} & \begin{bmatrix} 5.2 \\ 0.5 \\ 2.0 \\ 0.2 \\ 7.9 \\ 2.2 \\ 3.4 \\ 9.2 \\ \vdots \\ 7.0 \end{bmatrix} & \begin{bmatrix} 0.3 \\ 1.6 \\ 6.2 \\ 5.7 \\ 2.4 \\ 9.2 \\ 6.1 \\ 5.3 \\ \vdots \\ 5.8 \end{bmatrix} & \begin{bmatrix} 7.2 \\ 3.1 \\ 3.9 \\ 2.1 \\ 1.8 \\ 9.3 \\ 7.3 \\ 4.9 \\ \vdots \\ 2.3 \end{bmatrix} \end{matrix} \right.$$



Query

$$\begin{bmatrix} -3.7 & +3.9 & -2.4 & -6.3 & -9.4 & -8.6 & +3.6 & -0.9 & \dots & +0.7 \\ +7.9 & +9.7 & -5.6 & +3.2 & -4.7 & -9.5 & +5.1 & -3.6 & \dots & -2.3 \\ +1.7 & +6.6 & +2.6 & +7.4 & -4.5 & +5.9 & -6.2 & +9.0 & \dots & +3.7 \\ \vdots & \ddots & \vdots \\ -5.6 & +8.9 & +4.6 & -4.9 & -5.7 & +0.4 & -9.4 & -5.8 & \dots & -1.5 \end{bmatrix}$$

Key

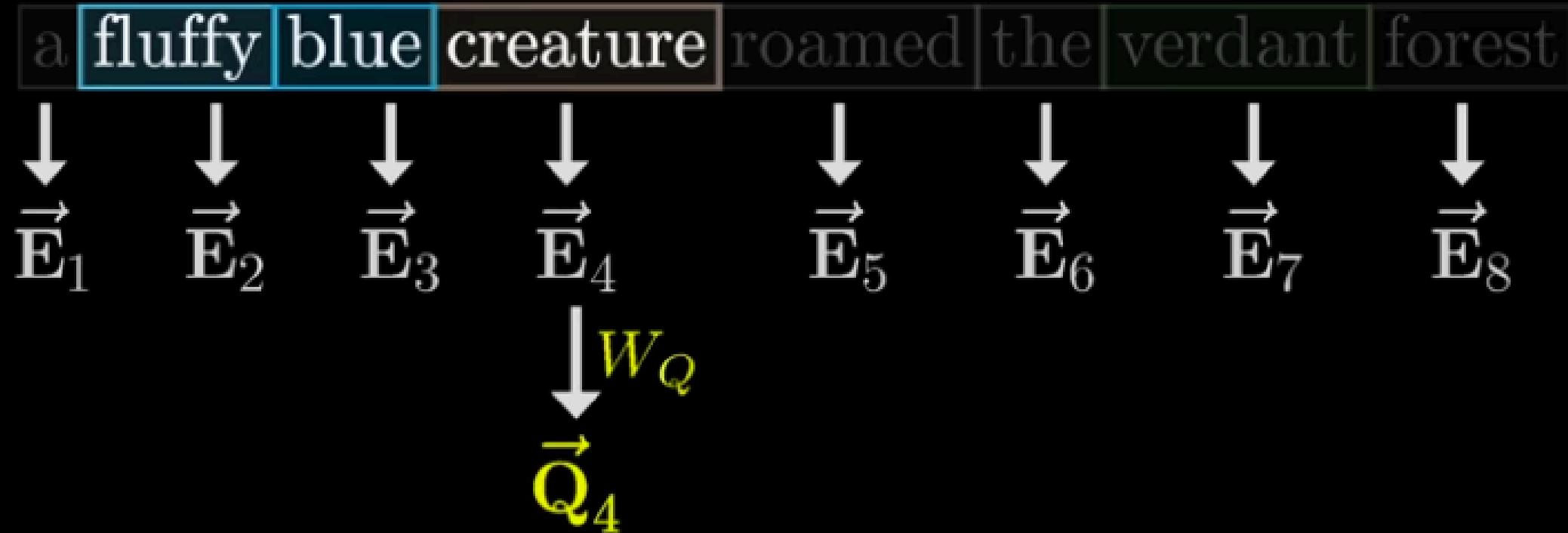
$$\begin{bmatrix} -2.5 & -0.7 & -4.4 & +1.7 & +7.2 & -7.6 & +0.3 & -7.3 & \dots & +4.3 \\ -2.1 & +1.3 & -6.3 & -7.0 & -0.2 & -2.9 & +8.7 & +5.3 & \dots & +4.9 \\ +8.0 & -8.2 & +1.0 & +1.7 & +9.1 & -4.1 & -5.1 & -7.9 & \dots & -9.6 \\ \vdots & \ddots & \vdots \\ +8.5 & +3.4 & +5.6 & -4.3 & +1.7 & -8.6 & -0.3 & +9.5 & \dots & +7.5 \end{bmatrix}$$

Value

$$\begin{bmatrix} -3.2 & +9.1 & -5.3 & +8.9 & +8.7 & +5.9 & +2.6 & +7.4 & \dots & -4.1 \\ +6.9 & +2.3 & -9.6 & -3.0 & -7.0 & +9.5 & -0.4 & -0.1 & \dots & +2.8 \\ -2.6 & -7.2 & +6.4 & -6.1 & +0.2 & -5.5 & -8.0 & +7.2 & \dots & +9.4 \\ +9.1 & +8.0 & +5.4 & -3.3 & -8.3 & -1.8 & -5.3 & -7.3 & \dots & -8.8 \\ +4.5 & -9.7 & +5.4 & -7.0 & -8.3 & -8.1 & +3.4 & -5.0 & \dots & -1.6 \\ +1.1 & +7.1 & +4.5 & -4.5 & -7.3 & -8.8 & -3.9 & -4.7 & \dots & -0.9 \\ +3.6 & +3.9 & -4.3 & -2.4 & -6.3 & +5.7 & -8.8 & +3.9 & \dots & +5.5 \\ +5.5 & -4.8 & -2.5 & +1.7 & -4.5 & -2.6 & -6.0 & -0.8 & \dots & -9.0 \\ \vdots & \ddots & \vdots \\ +5.9 & -8.4 & +0.4 & -3.8 & +1.5 & +9.1 & +2.9 & -9.2 & \dots & -1.4 \end{bmatrix}$$

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{\mathbf{K}^T Q}{\sqrt{d_k}}\right) V$$



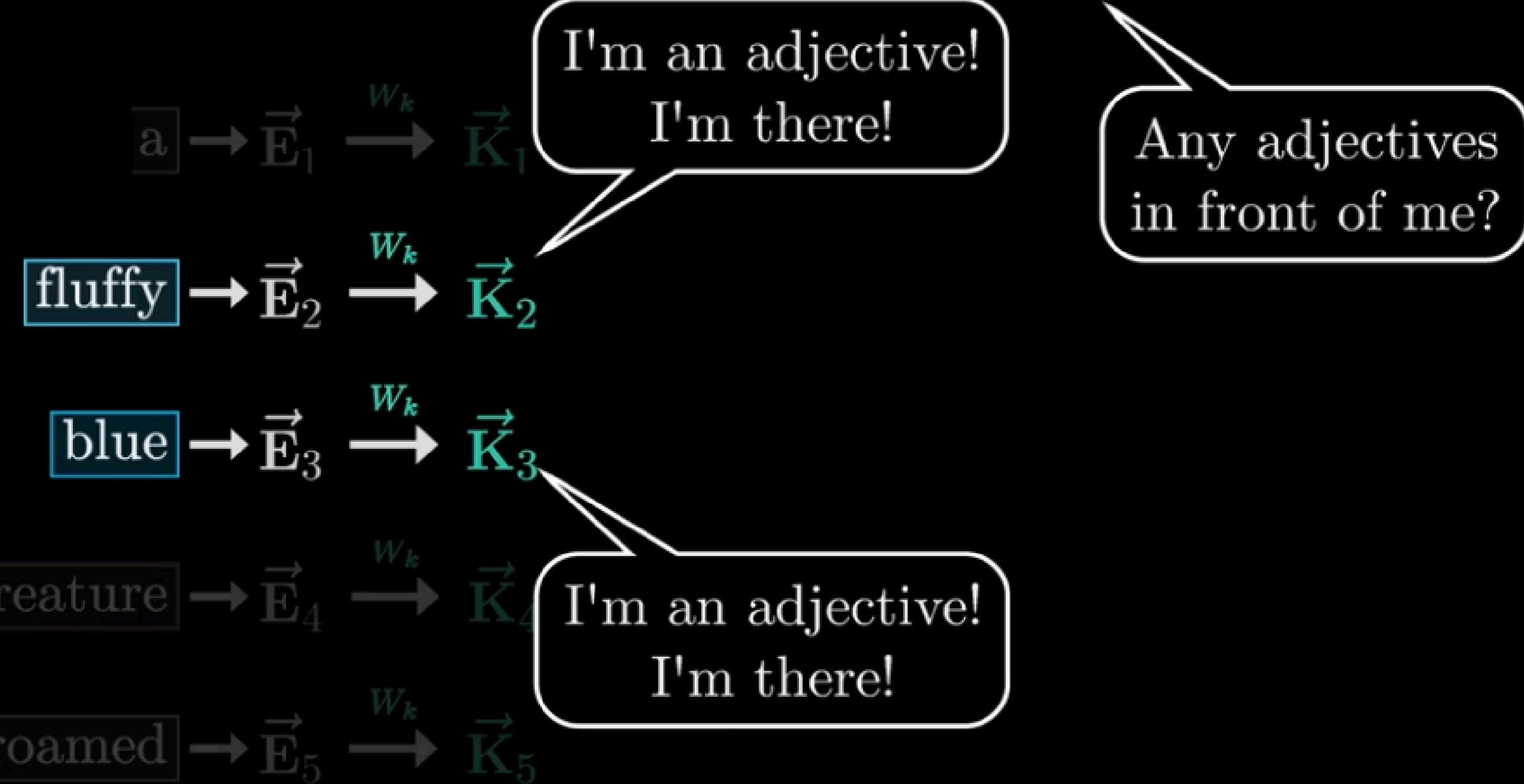
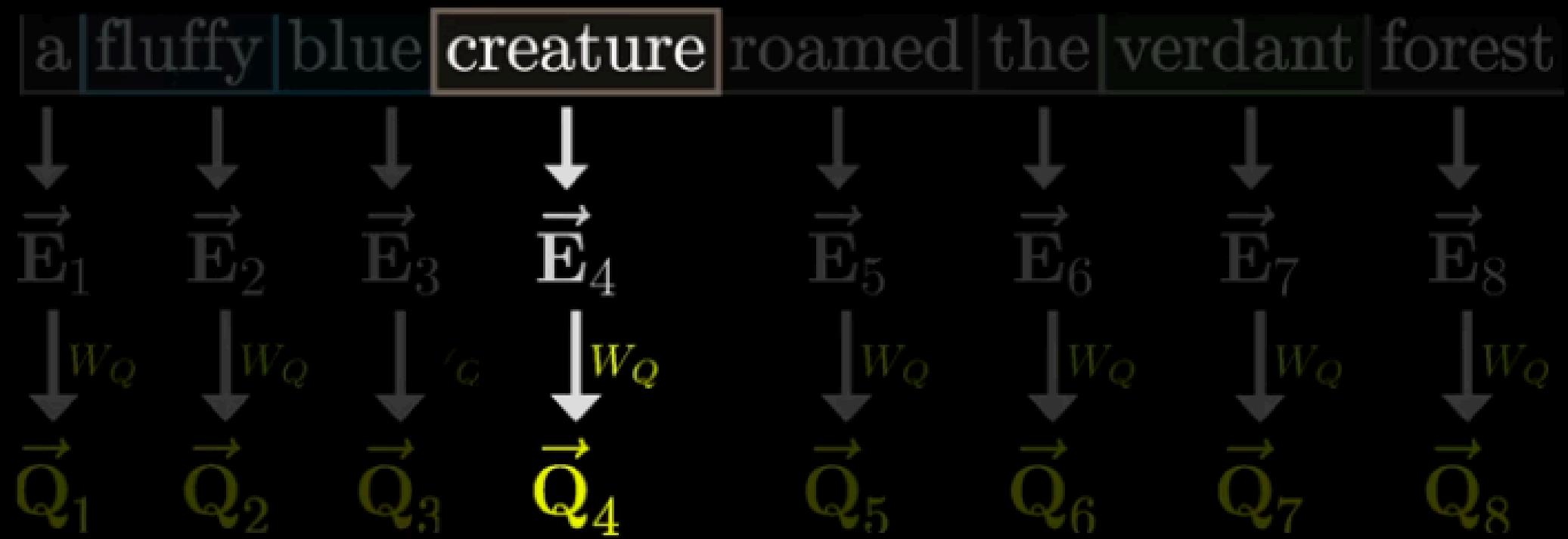


Any adjectives
in front of me?

$$\underbrace{W_Q}_{\begin{bmatrix} 2.9 \\ 2.4 \\ 1.0 \\ 0.2 \\ 9.2 \\ 6.6 \\ 7.8 \\ 2.8 \\ 5.8 \\ 0.6 \\ 9.7 \end{bmatrix}} = \vec{E}_4 \quad \vec{Q}_4$$

$$\begin{bmatrix}
 +7.5 & -3.2 & +9.1 & -5.3 & +8.9 & +8.7 & +5.9 & +2.6 & +7.4 & -4.1 & \dots & +2.3 \\
 -9.6 & -3.0 & -7.0 & +9.5 & -0.4 & -0.1 & +2.8 & -2.6 & -7.2 & +6.4 & \dots & +0.2 \\
 -5.5 & -8.0 & +7.2 & +9.4 & +9.1 & +8.0 & +5.4 & -3.3 & -8.3 & -1.8 & \dots & -7.3 \\
 -8.8 & +4.5 & -9.7 & +5.4 & -7.0 & -8.3 & -8.1 & +3.4 & -5.0 & -1.6 & \dots & +7.1 \\
 +4.5 & -4.5 & -7.3 & -8.8 & -3.9 & -4.7 & -0.9 & +3.6 & +3.9 & -4.3 & \dots & -6.3 \\
 \vdots & \ddots & \vdots & \vdots \\
 -9.0 & +5.9 & -8.4 & +0.4 & -3.8 & +1.5 & +9.1 & +2.9 & -9.2 & -1.4 & \dots & +0.7
 \end{bmatrix}$$



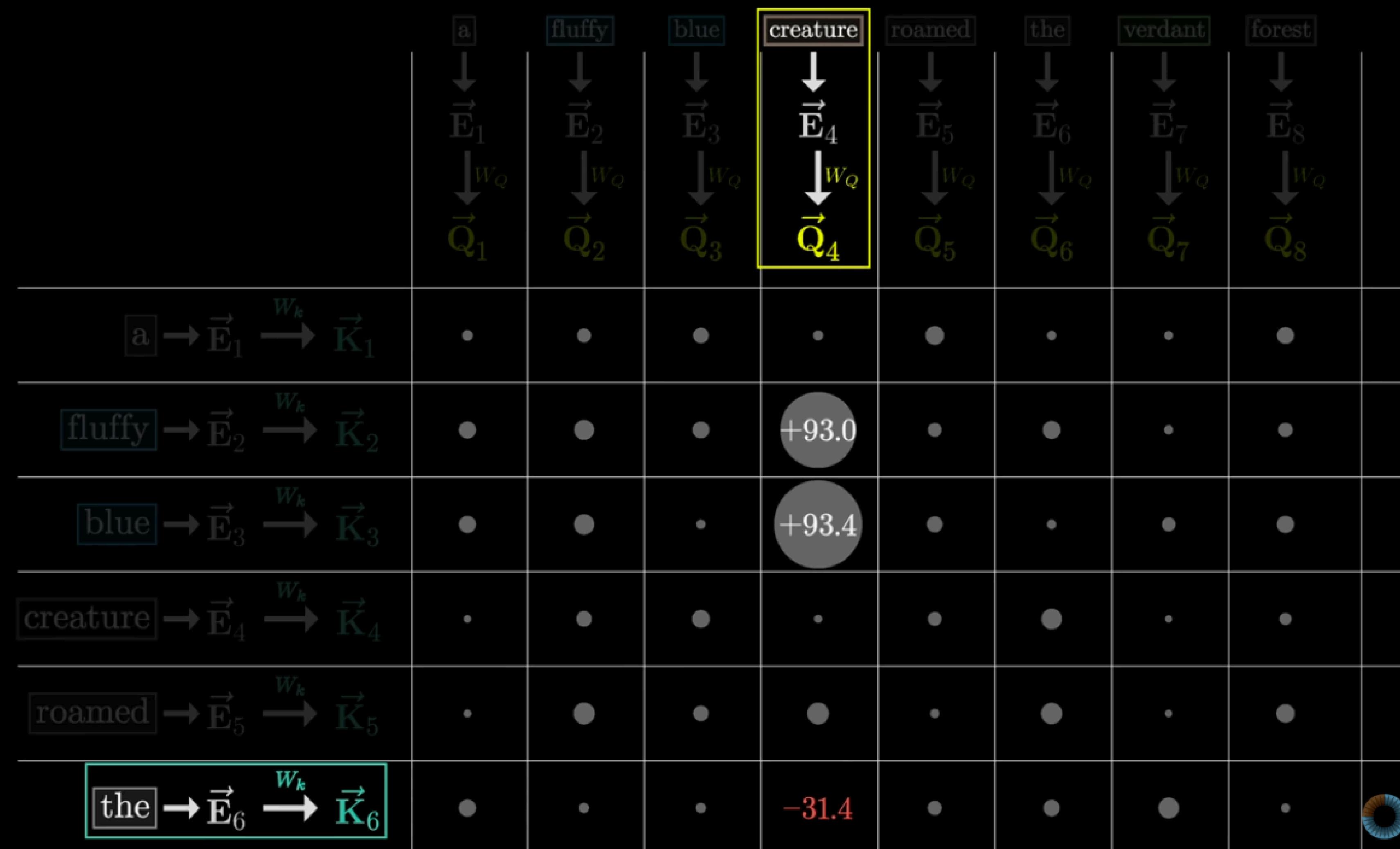


	a	fluffy	blue	creature	roamed	the	verdant	forest	
	\vec{E}_1 $\downarrow W_Q$ \vec{Q}_1	\vec{E}_2 $\downarrow W_Q$ \vec{Q}_2	\vec{E}_3 $\downarrow W_Q$ \vec{Q}_3	\vec{E}_4 $\downarrow W_Q$ \vec{Q}_4	\vec{E}_5 $\downarrow W_Q$ \vec{Q}_5	\vec{E}_6 $\downarrow W_Q$ \vec{Q}_6	\vec{E}_7 $\downarrow W_Q$ \vec{Q}_7	\vec{E}_8 $\downarrow W_Q$ \vec{Q}_8	
a	$\rightarrow \vec{E}_1 \xrightarrow{W_k} \vec{K}_1$	$\vec{K}_1 \cdot \vec{Q}_1$	$\vec{K}_1 \cdot \vec{Q}_2$	$\vec{K}_1 \cdot \vec{Q}_3$	$\vec{K}_1 \cdot \vec{Q}_4$	$\vec{K}_1 \cdot \vec{Q}_5$	$\vec{K}_1 \cdot \vec{Q}_6$	$\vec{K}_1 \cdot \vec{Q}_7$	$\vec{K}_1 \cdot \vec{Q}_8$
fluffy	$\rightarrow \vec{E}_2 \xrightarrow{W_k} \vec{K}_2$	$\vec{K}_2 \cdot \vec{Q}_1$	$\vec{K}_2 \cdot \vec{Q}_2$	$\vec{K}_2 \cdot \vec{Q}_3$	$\vec{K}_2 \cdot \vec{Q}_4$	$\vec{K}_2 \cdot \vec{Q}_5$	$\vec{K}_2 \cdot \vec{Q}_6$	$\vec{K}_2 \cdot \vec{Q}_7$	$\vec{K}_2 \cdot \vec{Q}_8$
blue	$\rightarrow \vec{E}_3 \xrightarrow{W_k} \vec{K}_3$	$\vec{K}_3 \cdot \vec{Q}_1$	$\vec{K}_3 \cdot \vec{Q}_2$	$\vec{K}_3 \cdot \vec{Q}_3$	$\vec{K}_3 \cdot \vec{Q}_4$	$\vec{K}_3 \cdot \vec{Q}_5$	$\vec{K}_3 \cdot \vec{Q}_6$	$\vec{K}_3 \cdot \vec{Q}_7$	$\vec{K}_3 \cdot \vec{Q}_8$
creature	$\rightarrow \vec{E}_4 \xrightarrow{W_k} \vec{K}_4$	$\vec{K}_4 \cdot \vec{Q}_1$	$\vec{K}_4 \cdot \vec{Q}_2$	$\vec{K}_4 \cdot \vec{Q}_3$	$\vec{K}_4 \cdot \vec{Q}_4$	$\vec{K}_4 \cdot \vec{Q}_5$	$\vec{K}_4 \cdot \vec{Q}_6$	$\vec{K}_4 \cdot \vec{Q}_7$	$\vec{K}_4 \cdot \vec{Q}_8$
roamed	$\rightarrow \vec{E}_5 \xrightarrow{W_k} \vec{K}_5$	$\vec{K}_5 \cdot \vec{Q}_1$	$\vec{K}_5 \cdot \vec{Q}_2$	$\vec{K}_5 \cdot \vec{Q}_3$	$\vec{K}_5 \cdot \vec{Q}_4$	$\vec{K}_5 \cdot \vec{Q}_5$	$\vec{K}_5 \cdot \vec{Q}_6$	$\vec{K}_5 \cdot \vec{Q}_7$	$\vec{K}_5 \cdot \vec{Q}_8$
the	$\rightarrow \vec{E}_6 \xrightarrow{W_k} \vec{K}_6$	$\vec{K}_6 \cdot \vec{Q}_1$	$\vec{K}_6 \cdot \vec{Q}_2$	$\vec{K}_6 \cdot \vec{Q}_3$	$\vec{K}_6 \cdot \vec{Q}_4$	$\vec{K}_6 \cdot \vec{Q}_5$	$\vec{K}_6 \cdot \vec{Q}_6$	$\vec{K}_6 \cdot \vec{Q}_7$	$\vec{K}_6 \cdot \vec{Q}_8$
verdant	$\rightarrow \vec{E}_7 \xrightarrow{W_k} \vec{K}_7$	$\vec{K}_7 \cdot \vec{Q}_1$	$\vec{K}_7 \cdot \vec{Q}_2$	$\vec{K}_7 \cdot \vec{Q}_3$	$\vec{K}_7 \cdot \vec{Q}_4$	$\vec{K}_7 \cdot \vec{Q}_5$	$\vec{K}_7 \cdot \vec{Q}_6$	$\vec{K}_7 \cdot \vec{Q}_7$	$\vec{K}_7 \cdot \vec{Q}_8$
forest	$\rightarrow \vec{E}_8 \xrightarrow{W_k} \vec{K}_8$	$\vec{K}_8 \cdot \vec{Q}_1$	$\vec{K}_8 \cdot \vec{Q}_2$	$\vec{K}_8 \cdot \vec{Q}_3$	$\vec{K}_8 \cdot \vec{Q}_4$	$\vec{K}_8 \cdot \vec{Q}_5$	$\vec{K}_8 \cdot \vec{Q}_6$	$\vec{K}_8 \cdot \vec{Q}_7$	$\vec{K}_8 \cdot \vec{Q}_8$

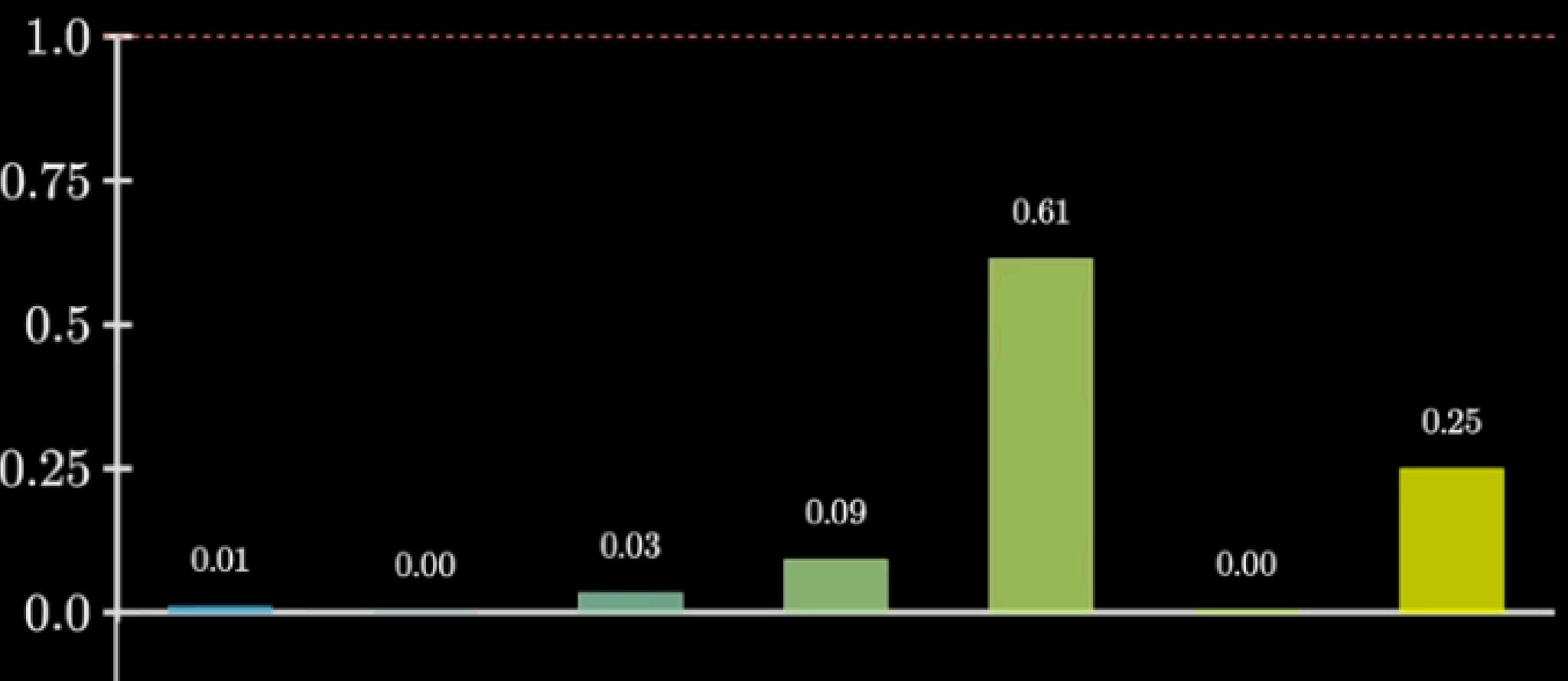


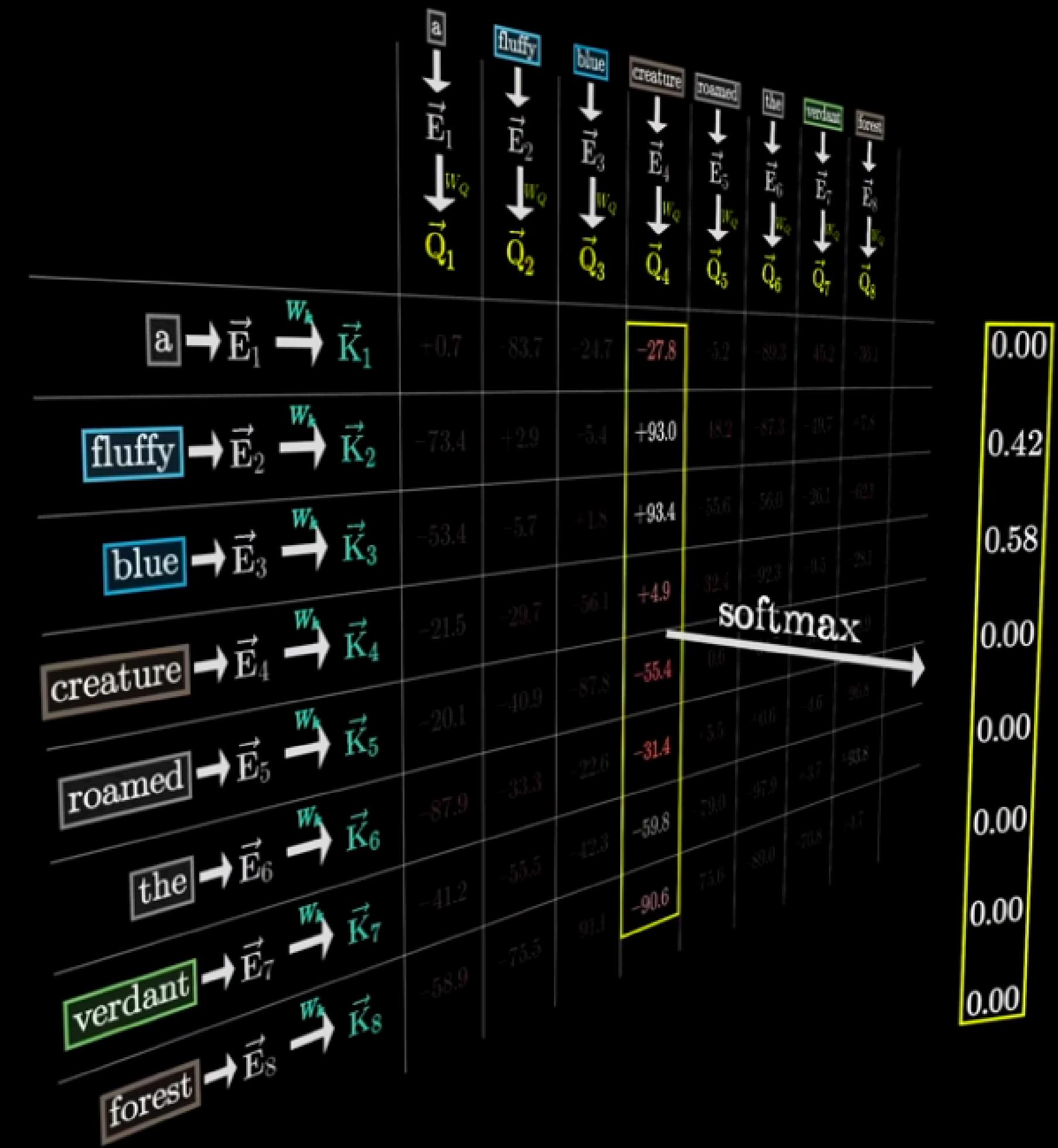
	a	fluffy	blue	creature	roamed	the	verdant	forest
	\downarrow							
	\vec{E}_1	\vec{E}_2	\vec{E}_3	\vec{E}_4	\vec{E}_5	\vec{E}_6	\vec{E}_7	\vec{E}_8
	$\downarrow W_Q$							
	\vec{Q}_1	\vec{Q}_2	\vec{Q}_3	\vec{Q}_4	\vec{Q}_5	\vec{Q}_6	\vec{Q}_7	\vec{Q}_8
$a \rightarrow \vec{E}_1 \xrightarrow{W_k} \vec{K}_1$	+0.7	-83.7	-24.7	-27.8	-5.2	-89.3	-45.2	-36.1
$\text{fluffy} \rightarrow \vec{E}_2 \xrightarrow{W_k} \vec{K}_2$	-73.4	+2.9	-5.4	+93.0	-48.2	-87.3	-49.7	+7.8
$\text{blue} \rightarrow \vec{E}_3 \xrightarrow{W_k} \vec{K}_3$	-53.4	-5.7	+1.8	+93.4	-55.6	-56.0	-26.1	-62.1
$\text{creature} \rightarrow \vec{E}_4 \xrightarrow{W_k} \vec{K}_4$	-21.5	-29.7	-56.1	+4.9	-32.4	-92.3	-9.5	-28.1
$\text{roamed} \rightarrow \vec{E}_5 \xrightarrow{W_k} \vec{K}_5$	-20.1	-40.9	-87.8	-55.4	+0.6	-64.7	-96.7	-18.9
$\text{the} \rightarrow \vec{E}_6 \xrightarrow{W_k} \vec{K}_6$	-87.9	-33.3	-22.6	-31.4	+5.5	+0.6	-4.6	-96.8
$\text{verdant} \rightarrow \vec{E}_7 \xrightarrow{W_k} \vec{K}_7$	-41.2	-55.5	-42.3	-59.8	-79.0	-97.9	+3.7	+93.8
$\text{forest} \rightarrow \vec{E}_8 \xrightarrow{W_k} \vec{K}_8$	-58.9	-75.5	-91.1	-90.6	-75.6	-89.0	-70.8	+4.7





creature	roamed	the	verdant	forest	
	$\downarrow \vec{E}_4$	$\downarrow \vec{E}_5$	$\downarrow \vec{E}_6$	$\downarrow \vec{E}_7$	$\downarrow \vec{E}_8$
	$\downarrow W_Q$				
	\vec{Q}_4	\vec{Q}_5	\vec{Q}_6	\vec{Q}_7	\vec{Q}_8
-27.8	-5.2	-89.3	-45.2	36.1	
+93.0					We want these to
+93.4	-5.5	-56.1	6.1		act like weights
+4.9	-32.4	-92.3	-9.5	-28.1	
-55.4	+0.6	-64.7	-96.7	-18.9	
-31.4	+5.5	+0.6	-4.6	-96.8	
-59.8	-79.0	-97.9	+3.7	+93.8	
-90.6	-75.6	-89.0	-70.8	+4.7	



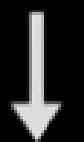


$$\text{Attention}(\mathbf{Q}, \mathbf{K}, \mathbf{V}) = \text{softmax} \left(\frac{\mathbf{K}^T \mathbf{Q}}{\sqrt{d_k}} \right) \mathbf{V}$$

	Q_1	Q_2	Q_3	Q_4	Q_5	\dots	Q_n	
K_1	$\frac{Q_1 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_1}{\sqrt{d_k}}$	\dots	$\frac{Q_n \cdot K_1}{\sqrt{d_k}}$	
K_2	$\frac{Q_1 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_2}{\sqrt{d_k}}$	\dots	$\frac{Q_n \cdot K_2}{\sqrt{d_k}}$	
K_3	$\frac{Q_1 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_3}{\sqrt{d_k}}$	\dots	$\frac{Q_n \cdot K_3}{\sqrt{d_k}}$	
K_4	$\frac{Q_1 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_4}{\sqrt{d_k}}$	\dots	$\frac{Q_n \cdot K_4}{\sqrt{d_k}}$	
K_5	$\frac{Q_1 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_5}{\sqrt{d_k}}$	\dots	$\frac{Q_n \cdot K_5}{\sqrt{d_k}}$	
\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\dots	\vdots	



fluffy creature

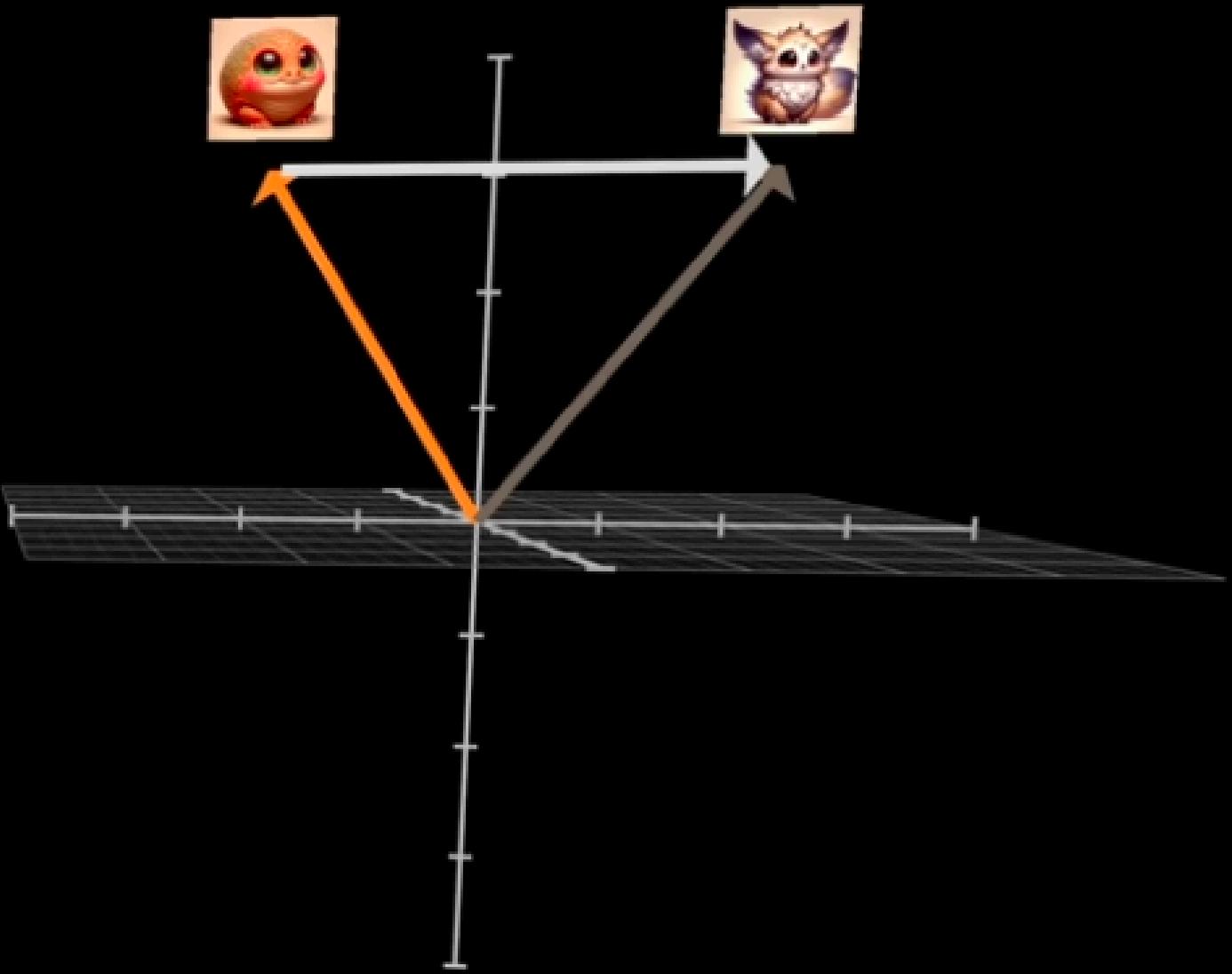


$$\begin{bmatrix} +9.2 \\ -2.3 \\ +5.8 \\ +0.6 \\ +1.3 \\ +8.4 \\ \vdots \\ -8.2 \end{bmatrix} \quad \begin{bmatrix} -7.6 \\ +2.8 \\ -7.1 \\ +8.8 \\ +0.4 \\ -1.7 \\ \vdots \\ -4.7 \end{bmatrix}$$

W_V

$$\left[\begin{array}{ccccccccc} -3.6 & -1.7 & -8.6 & +3.8 & +1.3 & -4.6 & \cdots & -8.0 \\ +1.5 & +8.5 & -3.6 & +3.3 & -7.3 & +4.3 & \cdots & -6.3 \\ +1.7 & -9.5 & +6.5 & -9.8 & +3.5 & -4.6 & \cdots & +9.2 \\ -5.0 & +1.5 & +1.8 & +1.4 & -5.5 & +9.0 & \cdots & +6.9 \\ +3.9 & -4.0 & +6.2 & -2.0 & +7.5 & +1.6 & \cdots & +3.8 \\ +4.5 & +0.0 & +9.0 & +2.9 & -1.5 & +2.1 & \cdots & -3.9 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ +1.5 & +3.0 & +3.0 & -1.4 & +7.9 & -2.6 & \cdots & +7.8 \end{array} \right]$$

Value
Matrix





creature

$$\downarrow$$

$$\vec{E}_4$$

$$+$$

$$\Delta\vec{E}_4$$

||

$$\vec{E}'_4$$

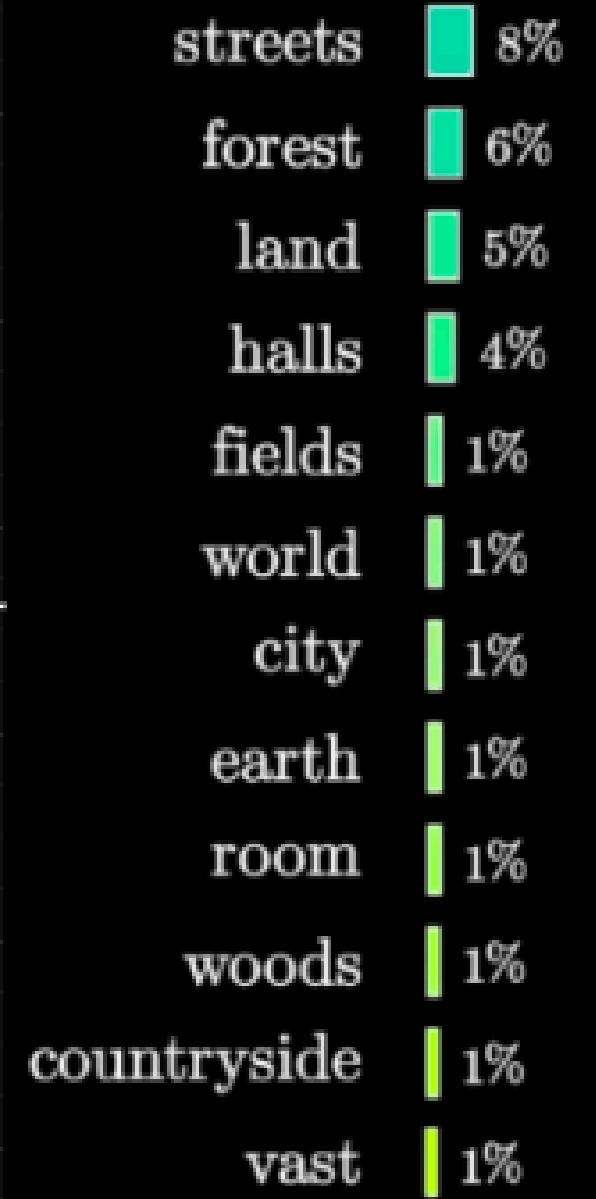
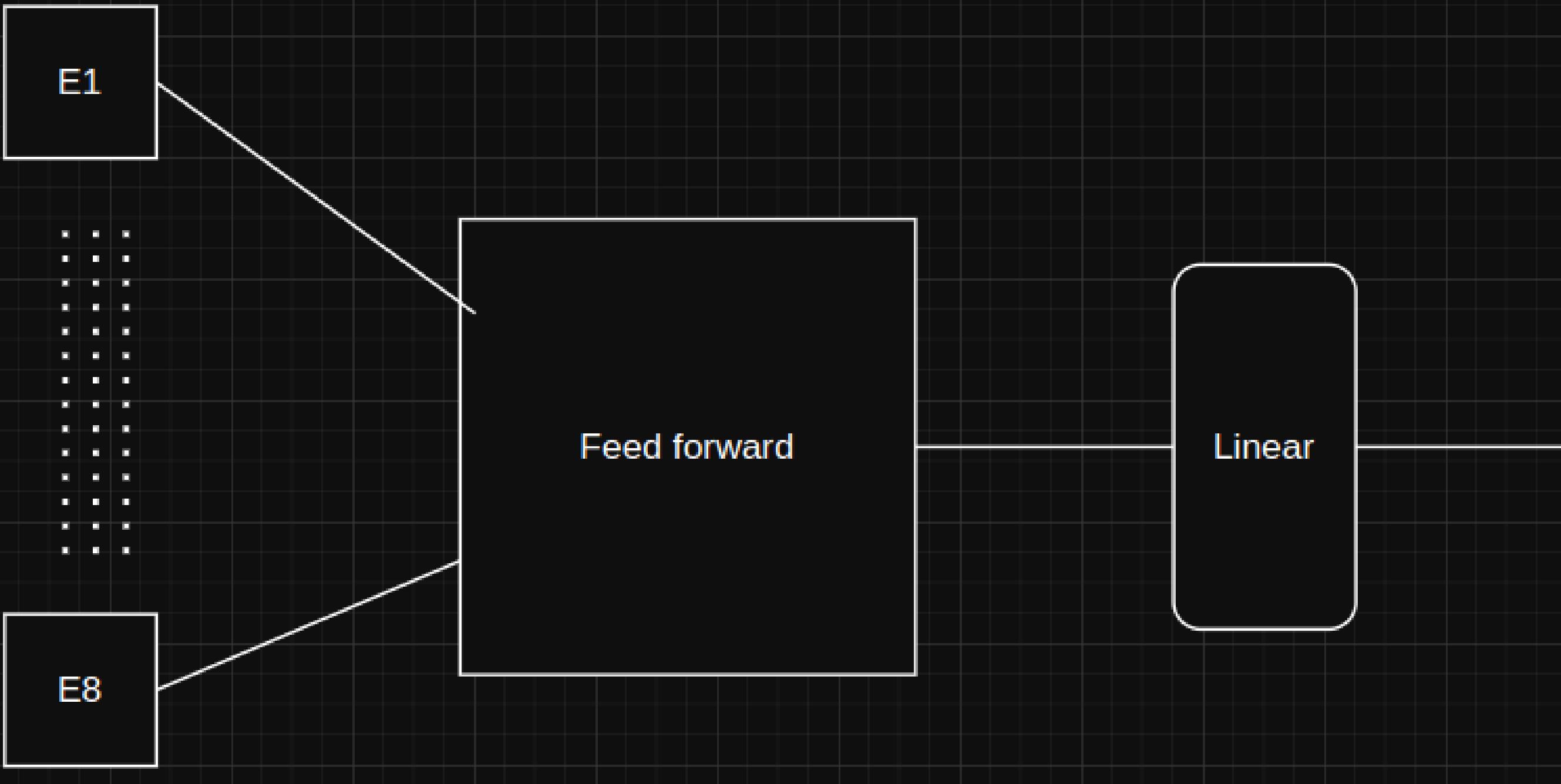


One head of attention

	a	duffy	blue	creature	rosamed	the	verdant	forest
	\downarrow							
$\vec{E}_1 \xrightarrow{w_v} \vec{v}_1$	1.00 \vec{v}_1	0.00 \vec{v}_1						
$\vec{E}_2 \xrightarrow{w_v} \vec{v}_2$	0.00 \vec{v}_2	1.00 \vec{v}_2	0.00 \vec{v}_2	0.42 \vec{v}_2	0.00 \vec{v}_2	0.00 \vec{v}_2	0.00 \vec{v}_2	0.00 \vec{v}_2
$\vec{E}_3 \xrightarrow{w_v} \vec{v}_3$	0.00 \vec{v}_3	0.00 \vec{v}_3	1.00 \vec{v}_3	0.58 \vec{v}_3	0.00 \vec{v}_3	0.00 \vec{v}_3	0.00 \vec{v}_3	0.00 \vec{v}_3
$\vec{E}_4 \xrightarrow{w_v} \vec{v}_4$	0.00 \vec{v}_4							
$\vec{E}_5 \xrightarrow{w_v} \vec{v}_5$	0.00 \vec{v}_5	0.00 \vec{v}_5	0.00 \vec{v}_5	0.00 \vec{v}_5	0.01 \vec{v}_5	0.00 \vec{v}_5	0.00 \vec{v}_5	0.00 \vec{v}_5
$\vec{E}_6 \xrightarrow{w_v} \vec{v}_6$	0.00 \vec{v}_6	0.00 \vec{v}_6	0.00 \vec{v}_6	0.00 \vec{v}_6	0.99 \vec{v}_6	1.00 \vec{v}_6	0.00 \vec{v}_6	0.00 \vec{v}_6
$\vec{E}_7 \xrightarrow{w_v} \vec{v}_7$	0.00 \vec{v}_7	1.00 \vec{v}_7	1.00 \vec{v}_7					
$\vec{E}_8 \xrightarrow{w_v} \vec{v}_8$	0.00 \vec{v}_8							
	$\Delta \vec{E}_1$	$\Delta \vec{E}_2$	$\Delta \vec{E}_3$	$\Delta \vec{E}_4$	$\Delta \vec{E}_5$	$\Delta \vec{E}_6$	$\Delta \vec{E}_7$	$\Delta \vec{E}_8$
	\vec{E}'_1	\vec{E}'_2	\vec{E}'_3	\vec{E}'_4	\vec{E}'_5	\vec{E}'_6	\vec{E}'_7	\vec{E}'_8

$$\begin{aligned}
& \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4 + \vec{E}_5 + \vec{E}_6 + \vec{E}_7 + \vec{E}_8 \\
&= \Delta \vec{E}_1 + \Delta \vec{E}_2 + \Delta \vec{E}_3 + \Delta \vec{E}_4 + \Delta \vec{E}_5 + \Delta \vec{E}_6 + \Delta \vec{E}_7 + \Delta \vec{E}_8 \\
&\quad \parallel \quad \parallel \\
&= \vec{E}'_1 + \vec{E}'_2 + \vec{E}'_3 + \vec{E}'_4 + \vec{E}'_5 + \vec{E}'_6 + \vec{E}'_7 + \vec{E}'_8
\end{aligned}$$





تولید توالی آمینواسیدها برای ساخت پروتئین با استفاده از مدل Transformer

The screenshot shows the UniProtKB search interface. The search term '(family:"acylphosphatase family")' is entered in the search bar. The results page displays 17,586 entries. A prominent yellow warning box at the top right states: 'The unreviewed UniProtKB/TrEMBL database will be reduced in size in release 2026_02 (first half of 2026).'. It details three categories of entries to be retained: 'Entries from reference proteomes', 'All reviewed (Swiss-Prot) entries', and 'Selected unreviewed (TrEMBL) entries with experimental or biologically important data'. Another section discusses entries to be removed: 'Entries to be removed: Unreviewed (TrEMBL) entries that are not part of a reference proteome'. Below this, a note says: 'Entries removed from unreviewed UniProtKB/TrEMBL will remain accessible in the UniParc sequence archive. Read our help page, view affected entries and proteomes, or contact us with any questions.' The main results table has columns for Entry, Entry Name, Protein Names, Gene Names, and Organism. Several entries for Acylphosphatase-1 and Acylphosphatase-2 from various species like Homo sapiens, Rattus norvegicus, Escherichia coli, Bos taurus, Meleagris gallopavo, and Sus scrofa are listed.

Entry	Entry Name	Protein Names	Gene Names	Organism
P14621	ACYP2_HUMAN	Acylphosphatase-2	ACYP2, ACYP	Homo sapiens (Human)
P07311	ACYP1_HUMAN	Acylphosphatase-1	ACYP1, ACYPE	Homo sapiens (Human)
P35745	ACYP2_RAT	Acylphosphatase-2	Acyp2, Acyp	Rattus norvegicus (Rat)
POAB65	ACYP_ECOLI	Acylphosphatase[...]	yccX, b0968, JW5131	Escherichia coli (strain K12)
P41500	ACYP1_BOVIN	Acylphosphatase-1	ACYP1, ACYPE	Bos taurus (Bovine)
P00821	ACYP2_MELGA	Acylphosphatase-2	ACYP2	Meleagris gallopavo (Wild turkey)
P24540	ACYP1_PIG	Acylphosphatase-1	ACYP1, ACYPE	Sus scrofa (Pig)

uniprot

▪ معرفی UniProt:
پایگاه داده جامع پروتئین‌ها که شامل توالی، ساختار و عملکرد آن‌ها در موجودات مختلف است.

▪ دیتابست پروژه:
توالی‌های آمینواسیدی آنزیم استخراج شده از پایگاه UniProt.
▪ کاربرد:
کمک به طراحی و درک بهتر عملکرد آنزیم‌ها و تولید پروتئین‌های مصنوعی.

▪ هدف مدل:
تولید توالی‌های جدید آمینواسیدی مشابه Acylphosphatase با استفاده از مدل Transformer.