

COMP201

Computer Systems & Programming

Lecture #05 – Chars and Strings in C



KOÇ
UNIVERSITY

Aykut Erdem // Koç University // Spring 2021



Good news, everyone!

- **TA Office Hours**

- Ahmed (Lab A)

- Wed 16:00-17:00

- Farzin (Lab B)

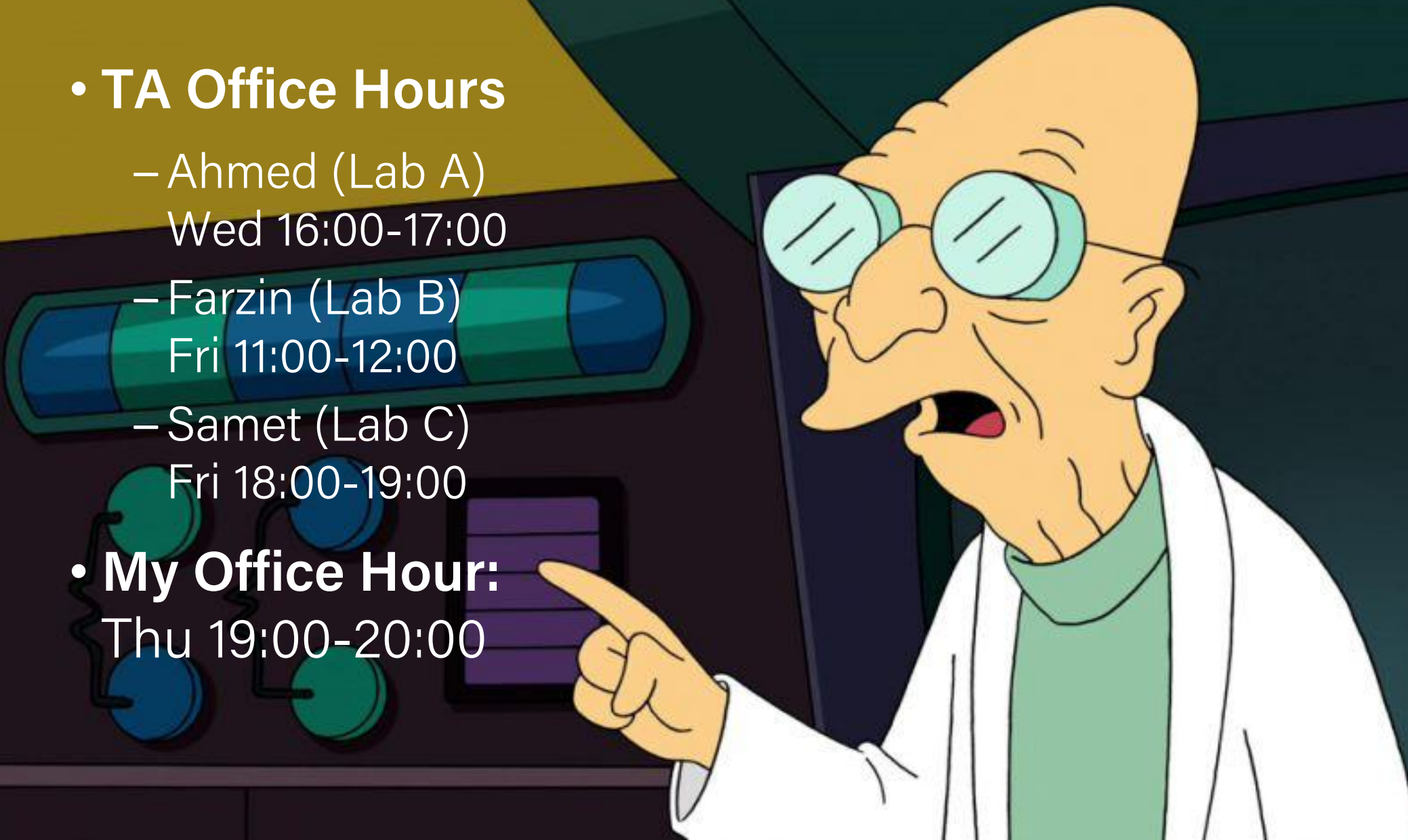
- Fri 11:00-12:00

- Samet (Lab C)

- Fri 18:00-19:00

- **My Office Hour:**

- Thu 19:00-20:00



COMP201 Topic 3: How can a
computer represent and
manipulate more complex data
like text?

Plan for Today

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

Disclaimer: Slides for this lecture were borrowed from

—Nick Troccoli and Lisa Yan's Stanford CS107 class

—Swami Iyer's Umass Boston CS110 class

Lecture Plan

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

Char

A **char** is a variable type that represents a single character or “glyph”.

```
char letterA = 'A';
```

```
char plus = '+';
```

```
char zero = '0';
```

```
char space = ' ';
```

```
char newLine = '\n';
```

```
char tab = '\t';
```

```
char singleQuote = '\'';
```

```
char backSlash = '\\';
```

ASCII

Under the hood, C represents each **char** as an 8-bit *integer* (its "ASCII value").

- Uppercase letters are sequentially numbered
- Lowercase letters are sequentially numbered
- Digits are sequentially numbered
- Lowercase letters are 32 more than their uppercase equivalents (bit flip!)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2	SP	!	"	#	\$	%	&	'	()	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[\]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{		}	~	DEL

Hexadecimal to ASCII conversion table

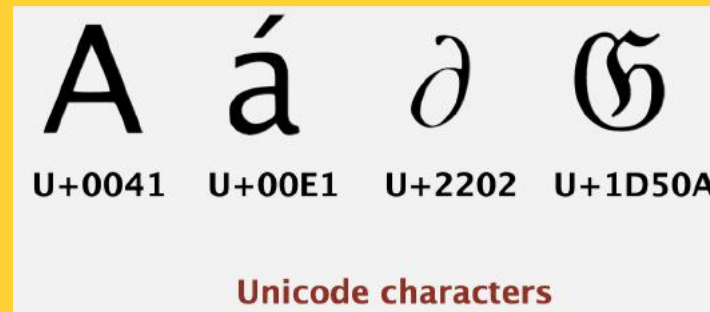
```
char uppercaseA = 'A'; // Actually 65
```

```
char lowercaseA = 'a'; // Actually 97
```

```
char zeroDigit = '0'; // Actually 48
```

























Unicode Transformation Formats

- The International Standards Organization's (ISO) 16-bit Unicode system can represent every character in every known language, with room for more
- Unicode being somewhat wasteful of space for English documents, ISO also defined several "Unicode Transformation Formats" (UTF), the most popular being UTF-8



Emojis

- Emojis are just like characters, and they have a standard, too

Smileys & People															
face-positive															
Nº	Code	Browser	App!	Goog ^d	Twtr.	One	FB	FBM	Sams.	Wind.	GMail	SB	DCM	KDDI	CLDR Short Name
1	U+1F600														grinning face
2	U+1F601														beaming face with smiling eyes
3	U+1F602														face with tears of joy
4	U+1F923														rolling on the floor laughing
5	U+1F603														grinning face with big eyes
6	U+1F604														grinning face with smiling eyes
7	U+1F605														grinning face with sweat
8	U+1F606														grinning squinting face
9	U+1F609														winking face
⋮															

- Full Emoji List, v5.0
<https://unicode.org/emoji/charts/full-emoji-list.html>

ASCII

We can take advantage of C representing each **char** as an *integer*:

```
bool areEqual = 'A' == 'A';           // true
bool earlierLetter = 'f' < 'c';        // false
char uppercaseB = 'A' + 1;
int diff = 'c' - 'a';                  // 2
int numLettersInAlphabet = 'z' - 'a' + 1;
// or
int numLettersInAlphabet = 'Z' - 'A' + 1;
```

ASCII

We can take advantage of C representing each **char** as an *integer*:

```
// prints out every lowercase character
for (char ch = 'a'; ch <= 'z'; ch++) {
    printf("%c", ch);
}
```

Common ctype.h Functions

Function	Description
isalpha(<i>ch</i>)	true if <i>ch</i> is 'a' through 'z' or 'A' through 'Z'
islower(<i>ch</i>)	true if <i>ch</i> is 'a' through 'z'
isupper(<i>ch</i>)	true if <i>ch</i> is 'A' through 'Z'
isspace(<i>ch</i>)	true if <i>ch</i> is a space, tab, new line, etc.
isdigit(<i>ch</i>)	true if <i>ch</i> is '0' through '9'
toupper(<i>ch</i>)	returns uppercase equivalent of a letter
tolower(<i>ch</i>)	returns lowercase equivalent of a letter

Remember: these **return a char**; they cannot modify an existing char!

More documentation with `man isalpha`, `man tolower`

Common ctype.h Functions

```
bool isLetter = isalpha( 'A' );           // true
bool capital = isupper( 'f' );           // false
char uppercaseB = toupper( 'b' );
bool isADigit = isdigit( '4' );          // true
```


Lecture Plan

- Characters
- **Strings**
- Common String Operations
- Practice: Diamonds

C Strings

C has no dedicated variable type for strings. Instead, a string is represented as an **array of characters** with a special ending sentinel value.

"Hello"	<i>index</i>	0	1	2	3	4	5
	<i>char</i>	'H'	'e'	'l'	'l'	'o'	'\0'

'\0' is the **null-terminating character**; you always need to allocate one extra space in an array for it.

String Length

Strings are **not** objects. They do not embed additional information (e.g., string length). We must calculate this!

<i>index</i>	0	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>value</i>	'H'	'e'	'l'	'l'	'o'	','	' '	'w'	'o'	'r'	'l'	'd'	'!'	'\0'

We can use the provided **strlen** function to calculate string length. The null-terminating character does *not* count towards the length.

```
int length = strlen(myStr);           // e.g. 13
```

Caution: `strlen` is $O(N)$ because it must scan the entire string! We should save the value if we plan to refer to the length later.

C Strings As Parameters

When we pass a string as a parameter, it is passed as a **char ***. C passes the location of the first character rather than a copy of the whole array.

```
int doSomething(char *str) {  
    ...  
}
```

```
char myString[6];  
...  
doSomething(myString);
```

C Strings As Parameters

When we pass a string as a parameter, it is passed as a **char ***. C passes the location of the first character rather than a copy of the whole array.

```
int doSomething(char *str) {  
    ...  
    str[0] = 'c'; // modifies original string!  
    printf("%s\n", str); // prints cello  
}
```

```
char myString[6];  
... // e.g. this string is "Hello"  
doSomething(myString);
```

We can still use a `char *` the same way as a `char []`.

Lecture Plan

- Characters
- Strings
- Common String Operations
 - Comparing
 - Copying
 - Concatenating
 - Substrings
- Practice: Diamonds

Common string.h Functions

Function	Description
strlen(<i>str</i>)	returns the # of chars in a C string (before null-terminating character).
strcmp(<i>str1</i> , <i>str2</i>), strncmp(<i>str1</i> , <i>str2</i> , <i>n</i>)	compares two strings; returns 0 if identical, <0 if <i>str1</i> comes before <i>str2</i> in alphabet, >0 if <i>str1</i> comes after <i>str2</i> in alphabet. strncmp stops comparing after at most <i>n</i> characters.
strchr(<i>str</i> , <i>ch</i>) strrchr(<i>str</i> , <i>ch</i>)	character search: returns a pointer to the first occurrence of <i>ch</i> in <i>str</i> , or NULL if <i>ch</i> was not found in <i>str</i> . strrchr find the last occurrence.
strstr(<i>haystack</i> , <i>needle</i>)	string search: returns a pointer to the start of the first occurrence of <i>needle</i> in <i>haystack</i> , or NULL if <i>needle</i> was not found in <i>haystack</i> .
strcpy(<i>dst</i> , <i>src</i>), strncpy(<i>dst</i> , <i>src</i> , <i>n</i>)	copies characters in <i>src</i> to <i>dst</i> , including null-terminating character. Assumes enough space in <i>dst</i> . Strings must not overlap. strncpy stops after at most <i>n</i> chars, and <u>does not</u> add null-terminating char.
strcat(<i>dst</i> , <i>src</i>), strncat(<i>dst</i> , <i>src</i> , <i>n</i>)	concatenate <i>src</i> onto the end of <i>dst</i> . strncat stops concatenating after at most <i>n</i> characters. <u>Always</u> adds a null-terminating character.
strspn(<i>str</i> , <i>accept</i>), strcspn(<i>str</i> , <i>reject</i>)	strspn returns the length of the initial part of <i>str</i> which contains <u>only</u> characters in <i>accept</i> . strcspn returns the length of the initial part of <i>str</i> which does <u>not</u> contain any characters in <i>reject</i> .

Common string.h Functions

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strstr(<i>haystack</i> , <i>needle</i>)	returns the first occurrence of <i>needle</i> in <i>haystack</i> , or NULL if not found in <i>haystack</i> .
strcpy(<i>dst</i> , <i>src</i>), strncpy(<i>dst</i> , <i>src</i> , <i>n</i>)	copies <i>src</i> to <i>dst</i> . Assumes enough space in <i>dst</i> . Strings must not overlap. strncpy stops after at most <i>n</i> chars, and <u>does not</u> add null-terminating char.
strcat(<i>dst</i> , <i>src</i>), strncat(<i>dst</i> , <i>src</i> , <i>n</i>)	concatenate <i>src</i> onto the end of <i>dst</i> . strncat stops concatenating after at most <i>n</i> characters. <u>Always</u> adds a null-terminating character.
strspn(<i>str</i> , <i>accept</i>), strcspn(<i>str</i> , <i>reject</i>)	strspn returns the length of the initial part of <i>str</i> which contains <u>only</u> characters in <i>accept</i> . strcspn returns the length of the initial part of <i>str</i> which does <u>not</u> contain any characters in <i>reject</i> .

Many string functions assume **valid string** input; i.e., ends in a null terminator.

Comparing Strings

We cannot compare C strings using comparison operators like `==`, `<` or `>`.
This compares addresses!

```
// e.g. str1 = 0x7f42, str2 = 0x654d
void doSomething(char *str1, char *str2) {
    if (str1 > str2) { ...    // compares 0x7f42 > 0x654d!
```

Instead, use **strcmp**.

The string library: strcmp

strcmp(str1, str2): compares two strings.

- returns 0 if identical
- <0 if **str1** comes before **str2** in alphabet
- >0 if **str1** comes after **str2** in alphabet.

```
int compResult = strcmp(str1, str2);
if (compResult == 0) {
    // equal
} else if (compResult < 0) {
    // str1 comes before str2
} else {
    // str1 comes after str2
}
```


Copying Strings

We cannot copy C strings using `=`. This copies addresses!

```
// e.g. param1 = 0x7f42, param2 = 0x654d
void doSomething(char *param1, char *param2) {
    param1 = param2;    // copies 0x654d. Points to same string!
    param2[0] = 'H';    // modifies the one original string!
```

Instead, use **strcpy**.

The string library: strcpy

strcpy(dst, src): copies the contents of **src** into the string **dst**, including the null terminator.

```
char str1[6];  
strcpy(str1, "hello");
```

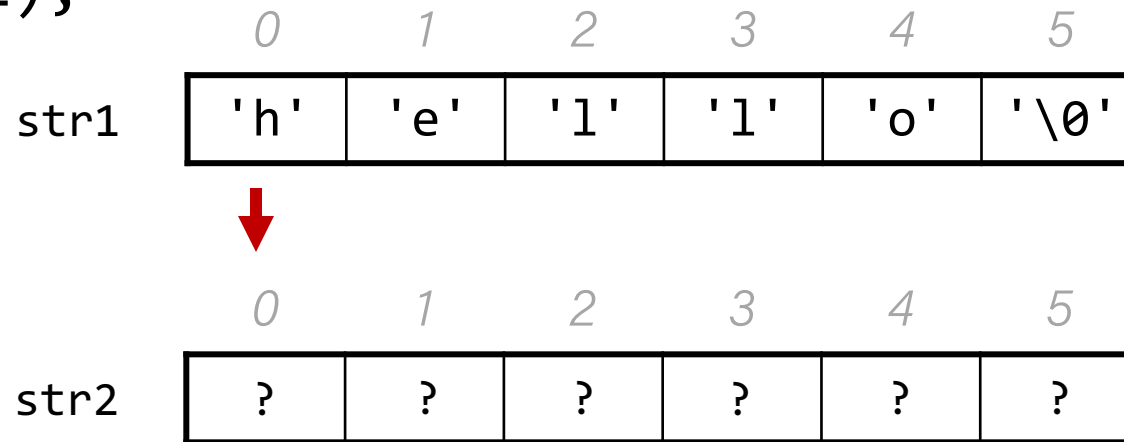
```
char str2[6];  
strcpy(str2, str1);  
str2[0] = 'c';
```

```
printf("%s", str1);    // hello  
printf("%s", str2);    // cello
```

Copying Strings – strcpy

```
char str1[6];  
strcpy(str1, "hello");
```

```
char str2[6];  
strcpy(str2, str1);
```



Copying Strings – strcpy

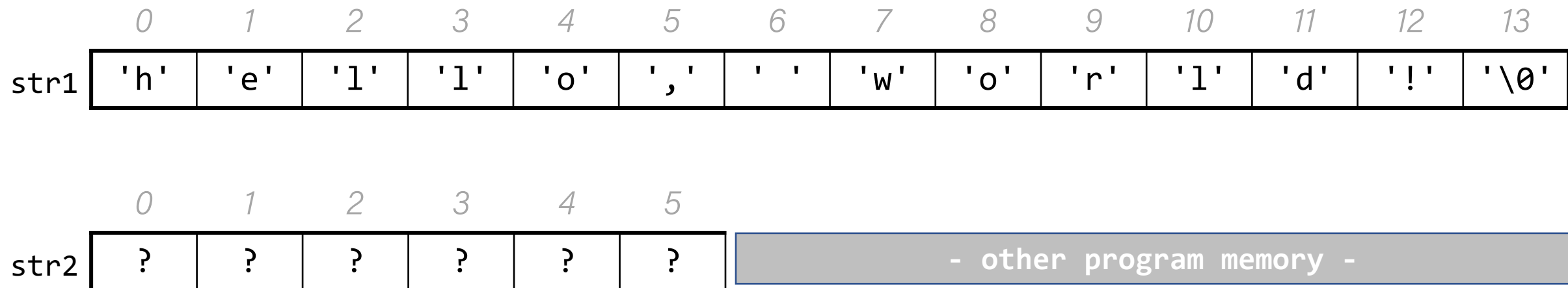
We must make sure there is enough space in the destination to hold the entire copy, *including the null-terminating character*.

```
char str2[6];           // not enough space!  
strcpy(str2, "hello, world!"); // overwrites other memory!
```

Writing past memory bounds is called a “buffer overflow”. It can allow for security vulnerabilities!

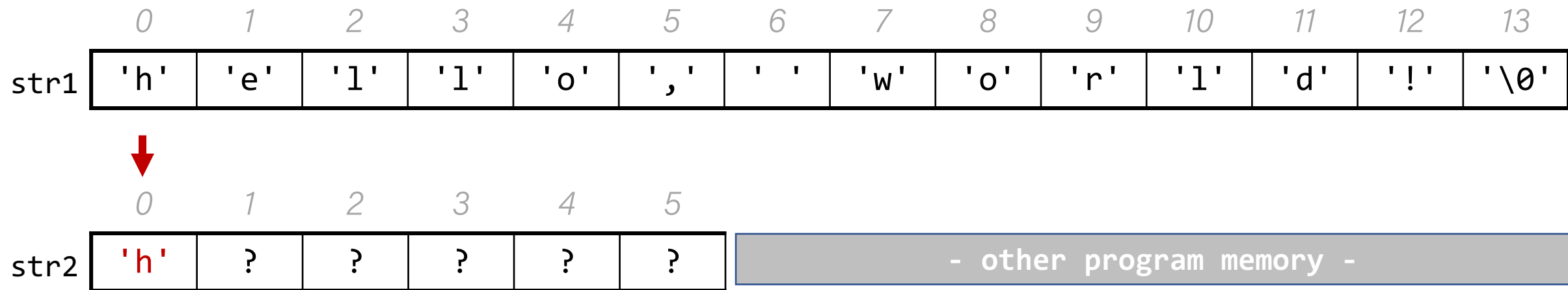
Copying Strings – Buffer Overflows

```
char str1[14];  
strcpy(str1, "hello, world!");  
char str2[6];  
strcpy(str2, str1);    // not enough space - overwrites other memory!
```



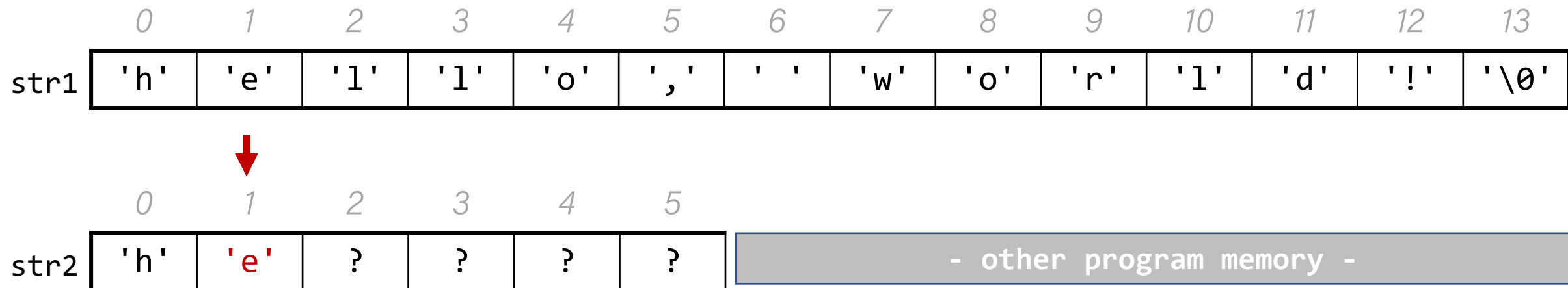
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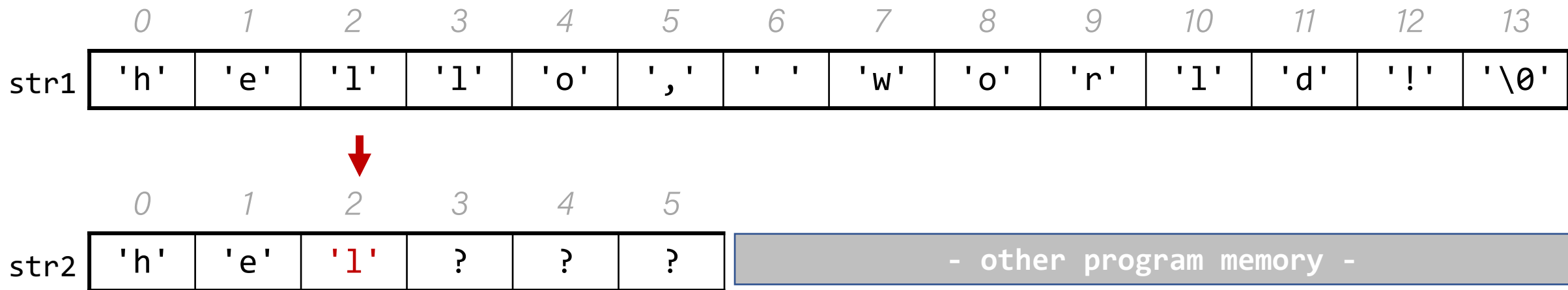
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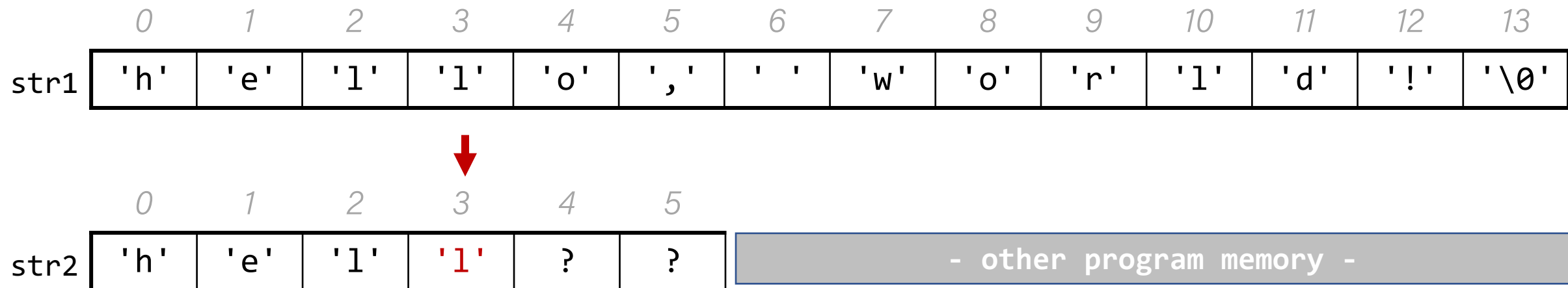
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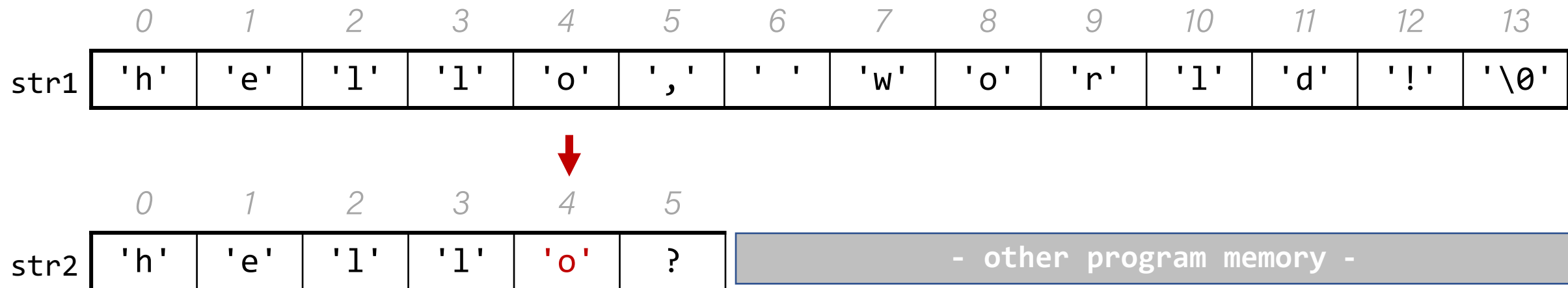
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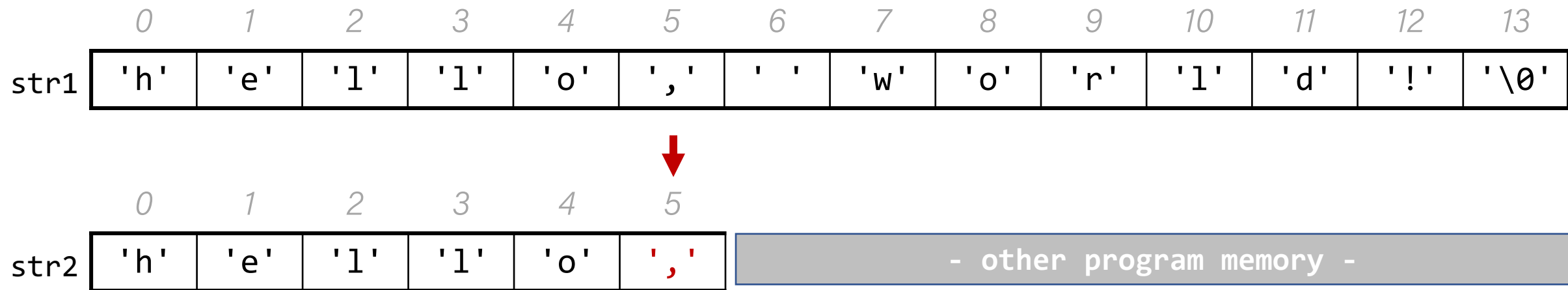
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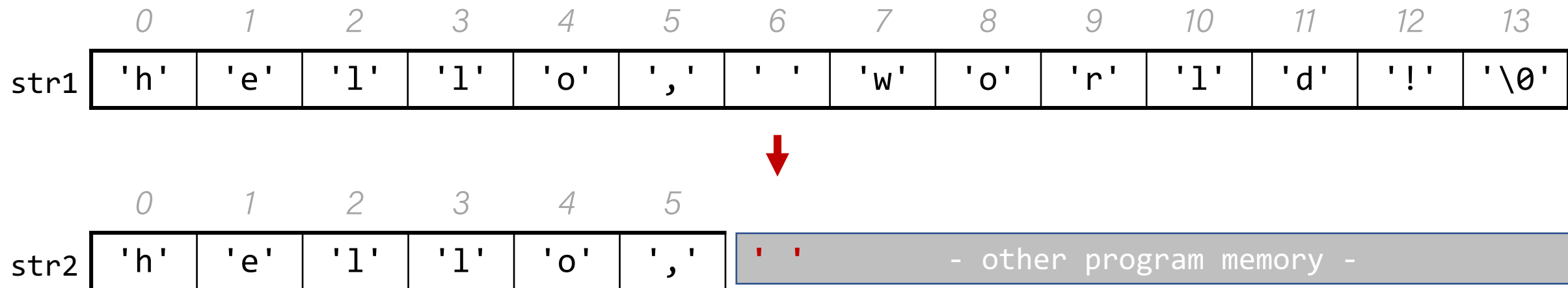
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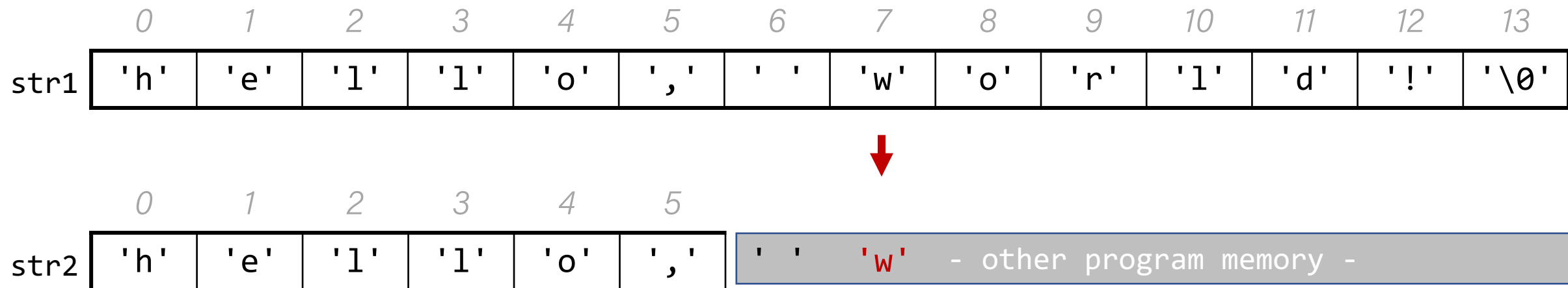
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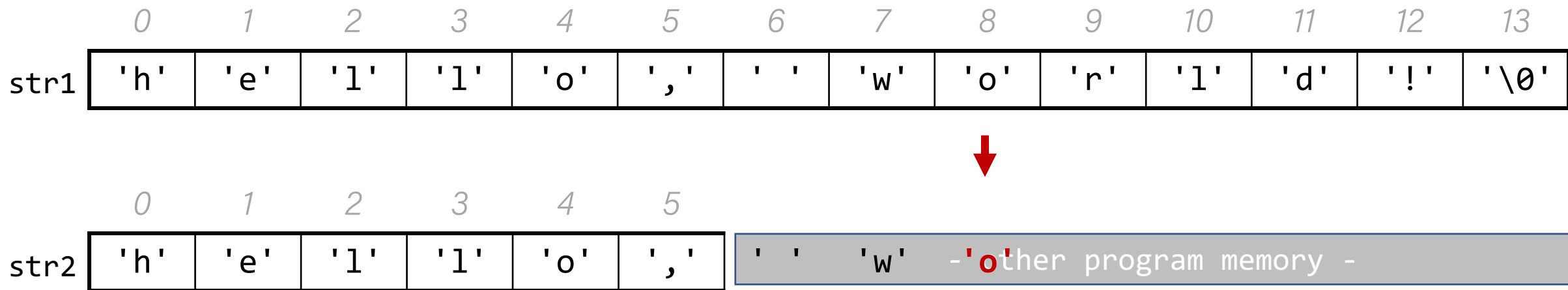
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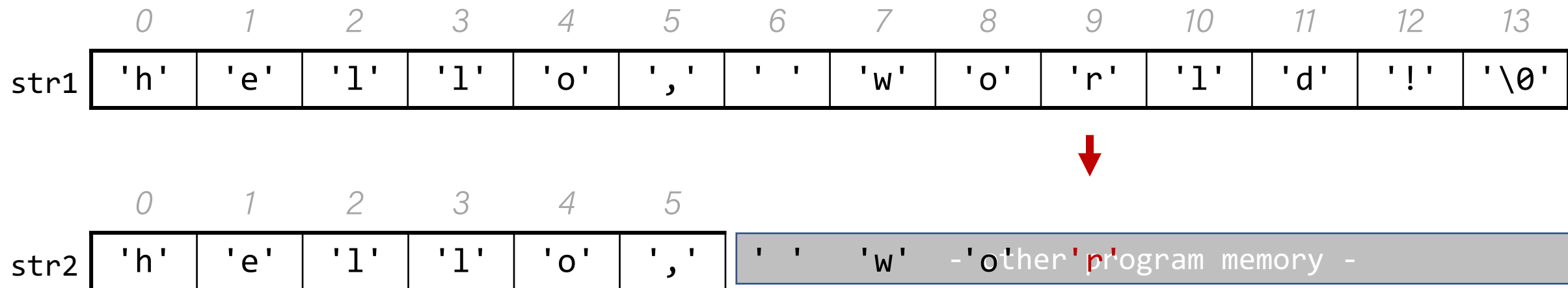
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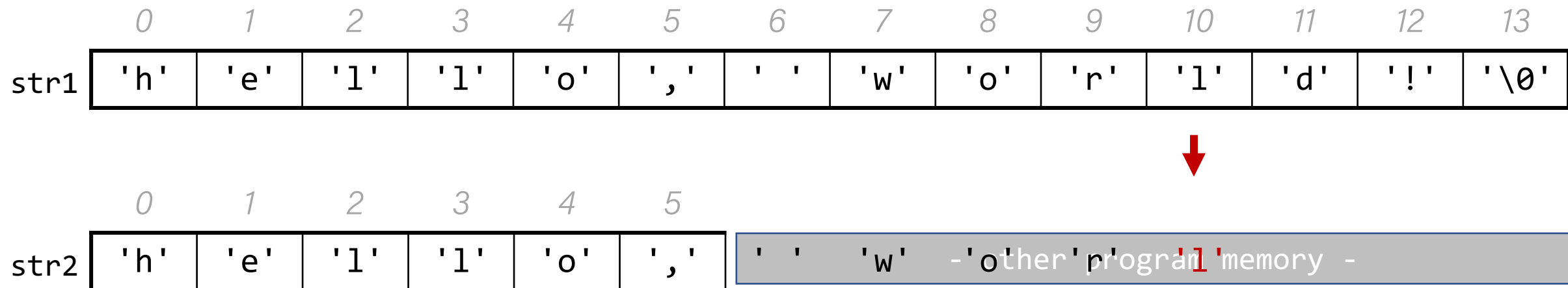
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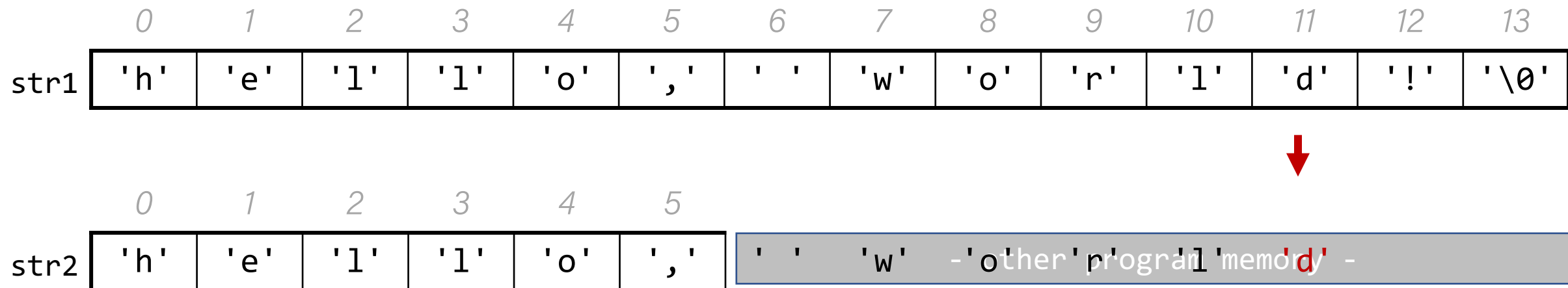
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```



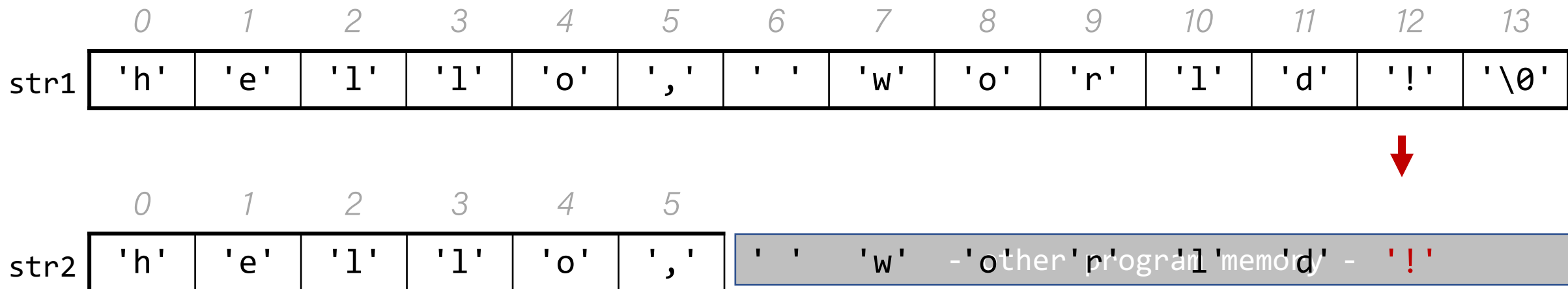
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```



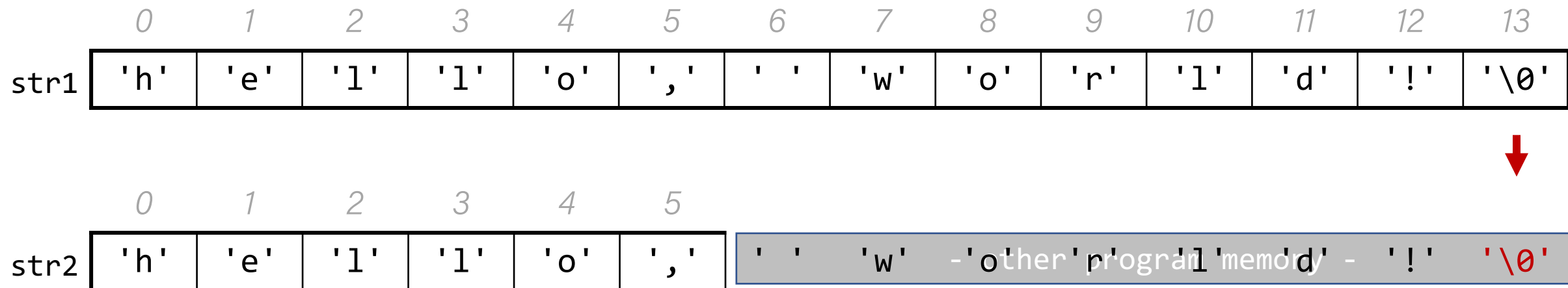
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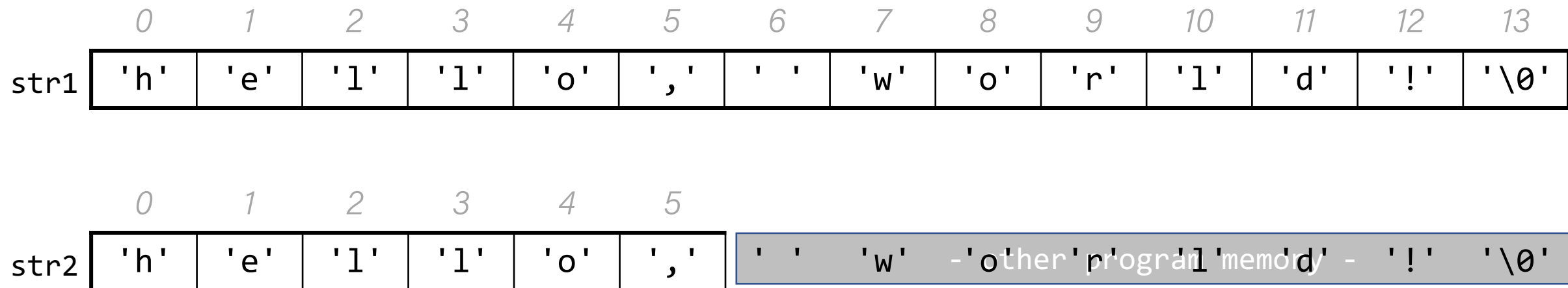
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Copying Strings – Buffer Overflows

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char str1[14];  
strcpy(str1, "hello, world!");  
char str2[6];  
strcpy(str2, str1);    // not enough space - overwrites other memory!
```



String Copying Exercise

What value should go in the blank at right?

- A. 4
- B. 5
- C. 6
- D. 12
- E. strlen("hello")
- F. Something else

```
char str[_____];  
strcpy(str, "hello");
```


String Exercise

What is printed out by the following program?

```
1  int main(int argc, char *argv[]) {  
2      char str[9];  
3      strcpy(str, "Hi earth");  
4      str[2] = '\0';  
5      printf("str = %s, len = %lu\n",  
6              str, strlen(str));  
7      return 0;  
8  }
```

A. str = Hi, len = 8
B. str = Hi, len = 2
C. str = Hi earth, len = 8
D. str = Hi earth, len = 2
E. None/other



Copying Strings – strncpy

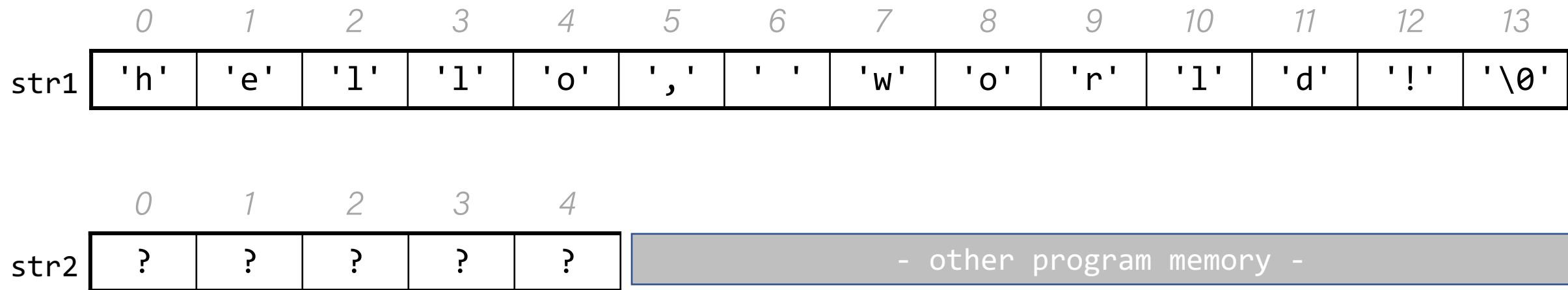
strncpy(dst, src, n): copies at most the first n bytes from **src** into the string **dst**. If there is no null-terminating character in these bytes, then **dst** will *not be null terminated*!

```
// copying "hello"  
char str2[5];  
strncpy(str2, "hello, world!", 5);    // doesn't copy '\0'!
```

If there is no null-terminating character, we may not be able to tell where the end of the string is anymore. E.g. `strlen` may continue reading into some other memory in search of `'\0'!`

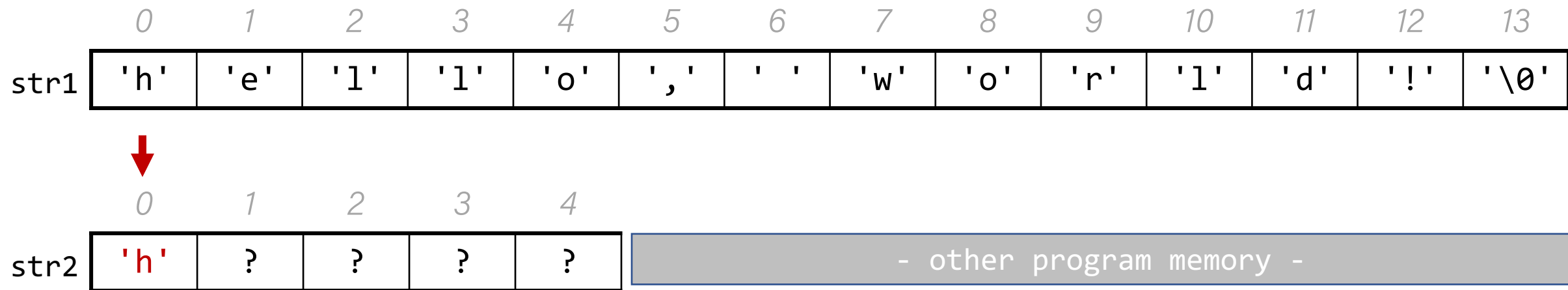
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



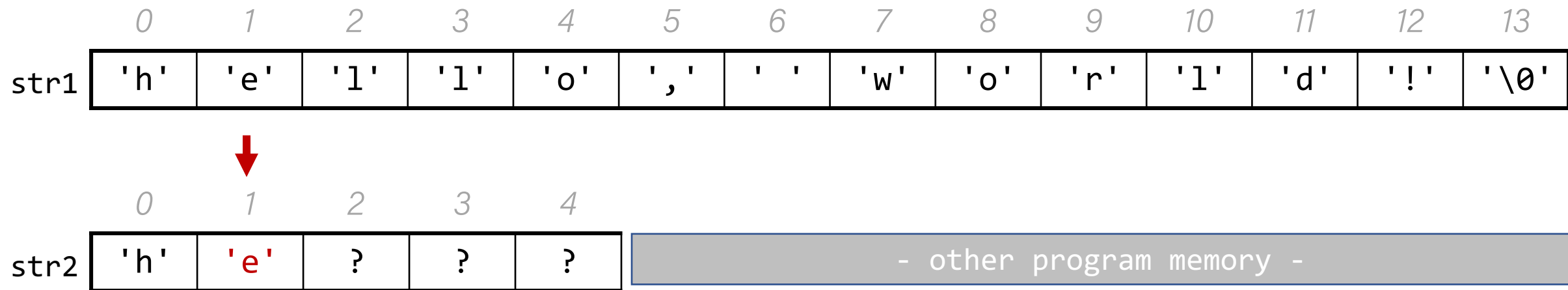
Copying Strings – strncpy

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int length = strlen(str2);
```



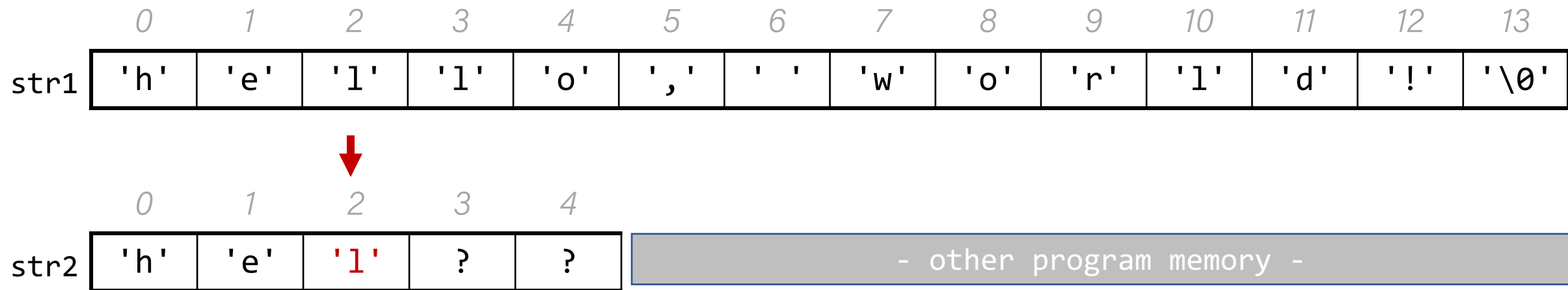
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



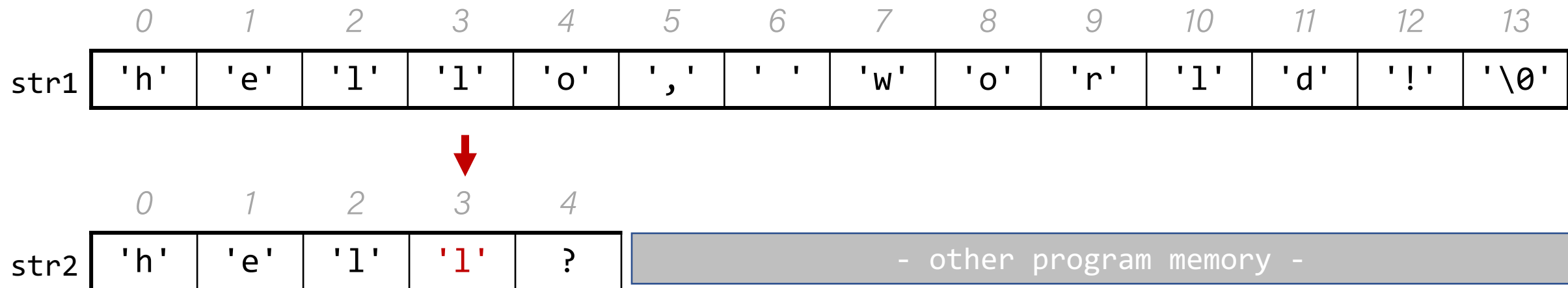
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



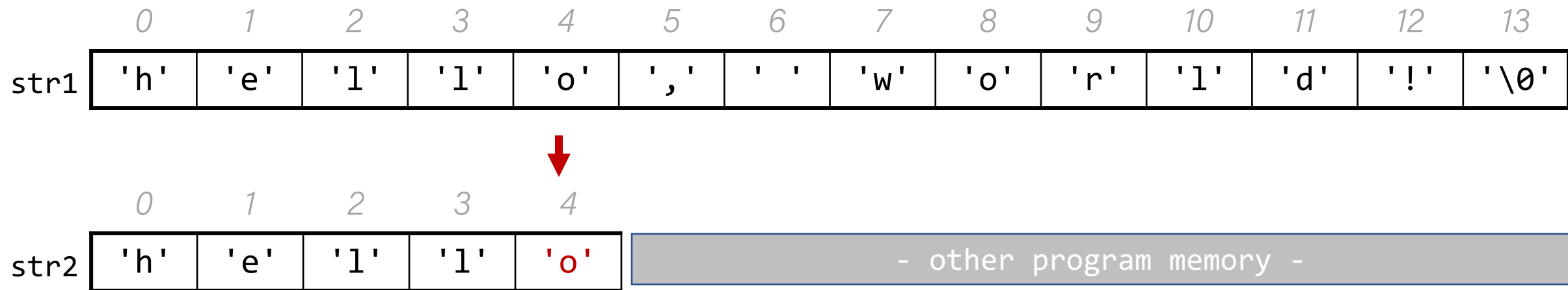
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



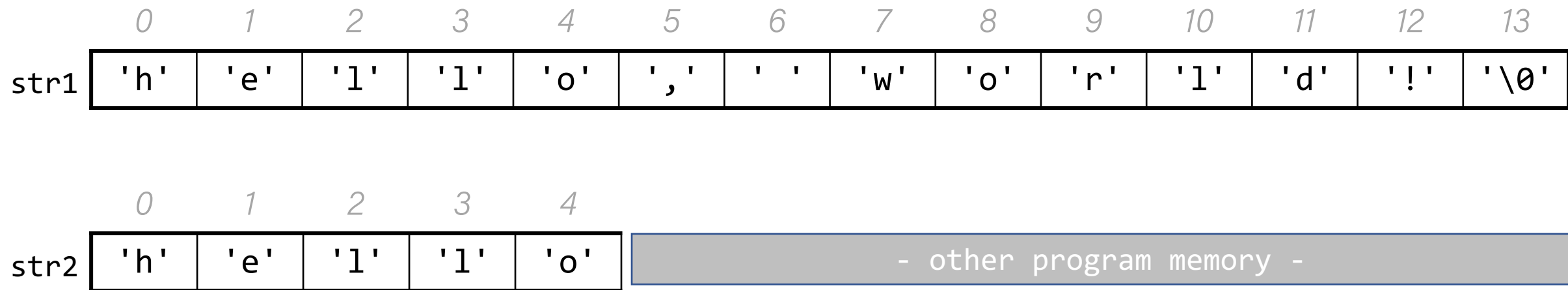
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



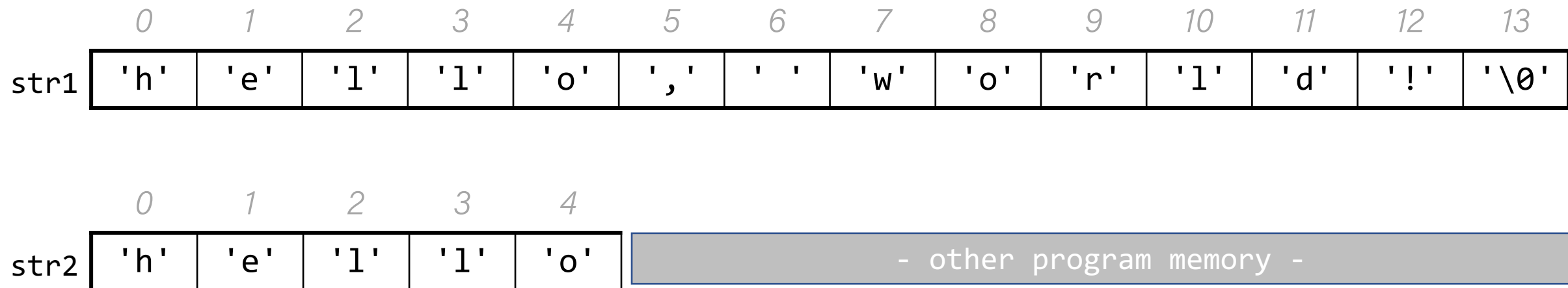
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



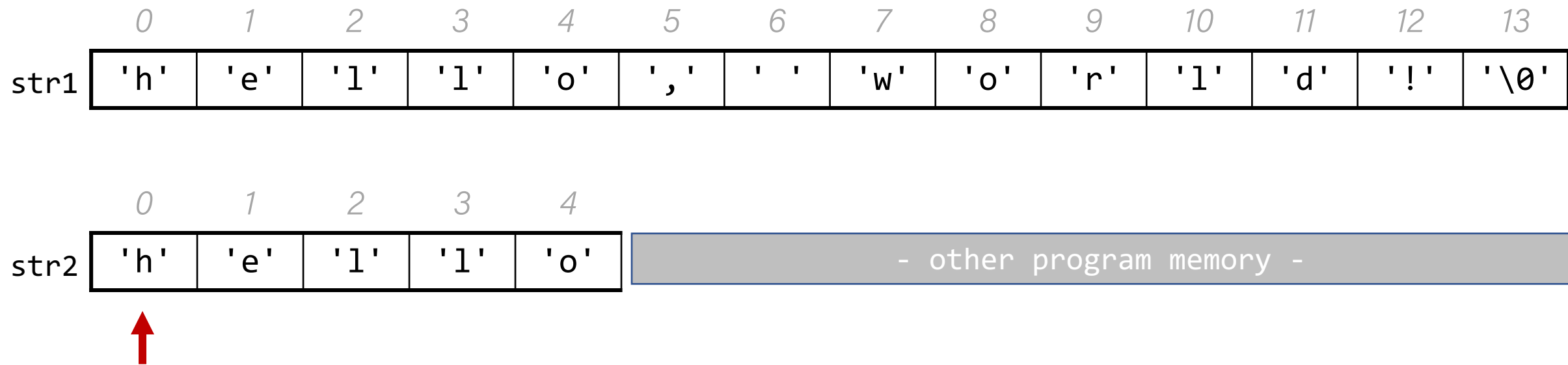
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



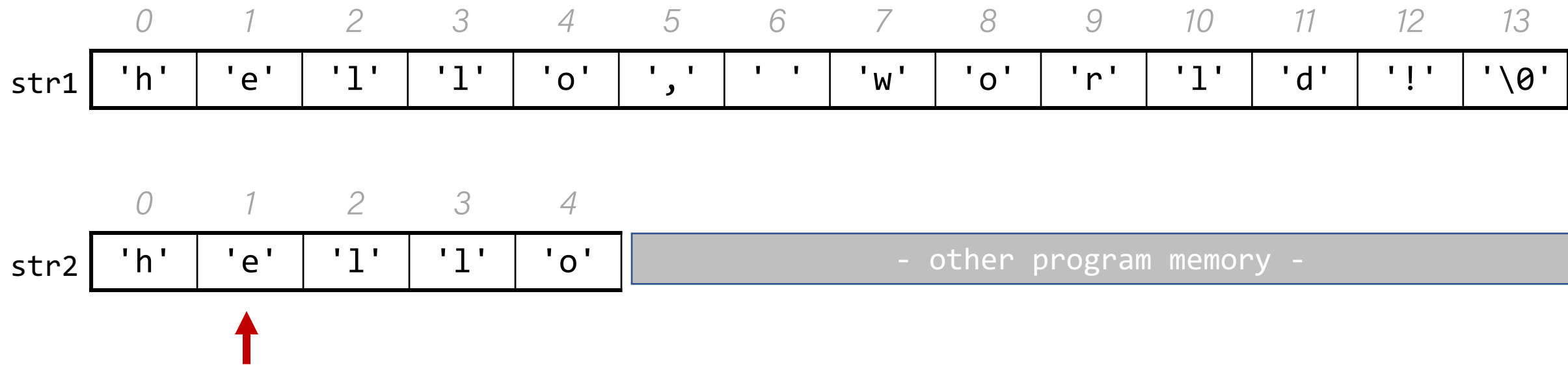
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



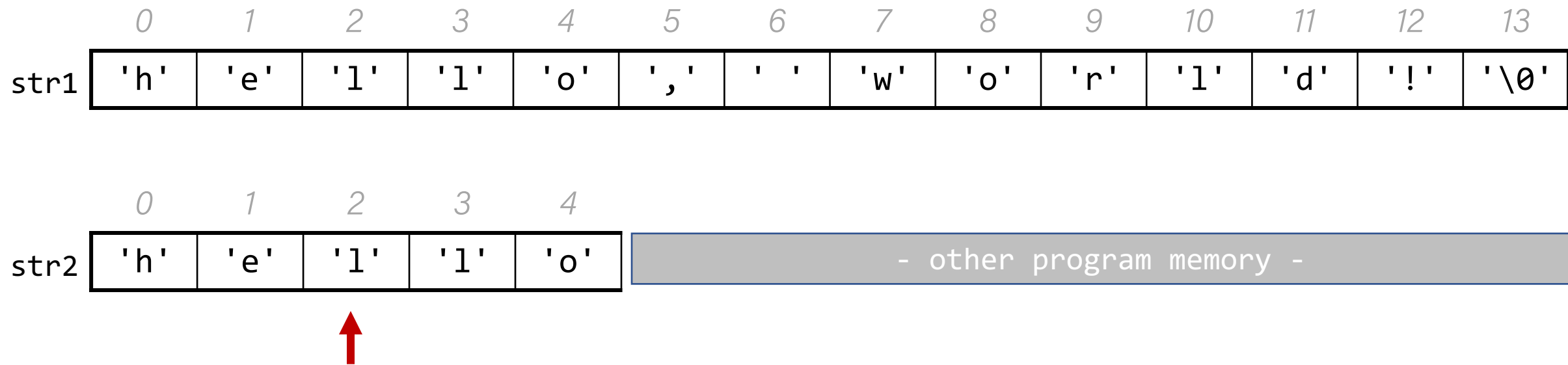
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



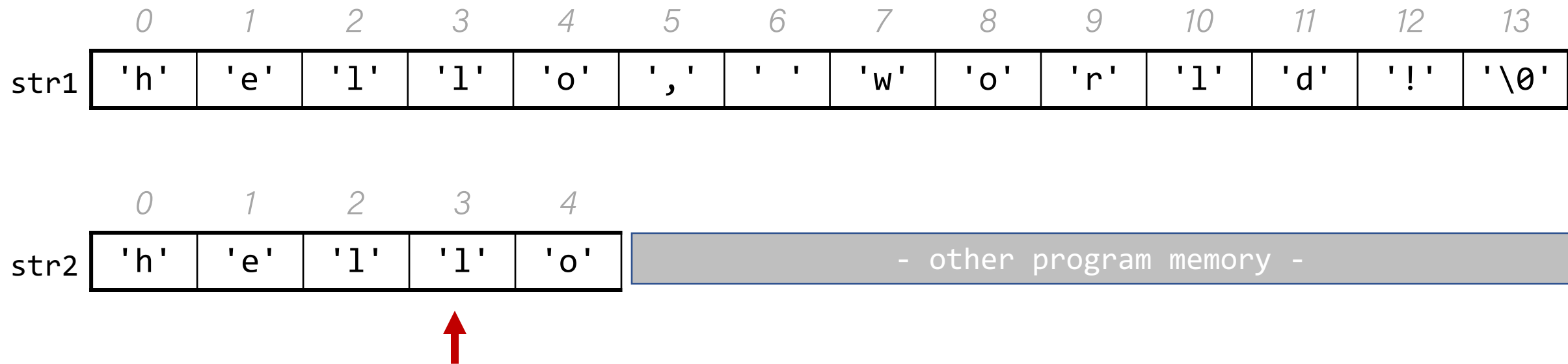
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



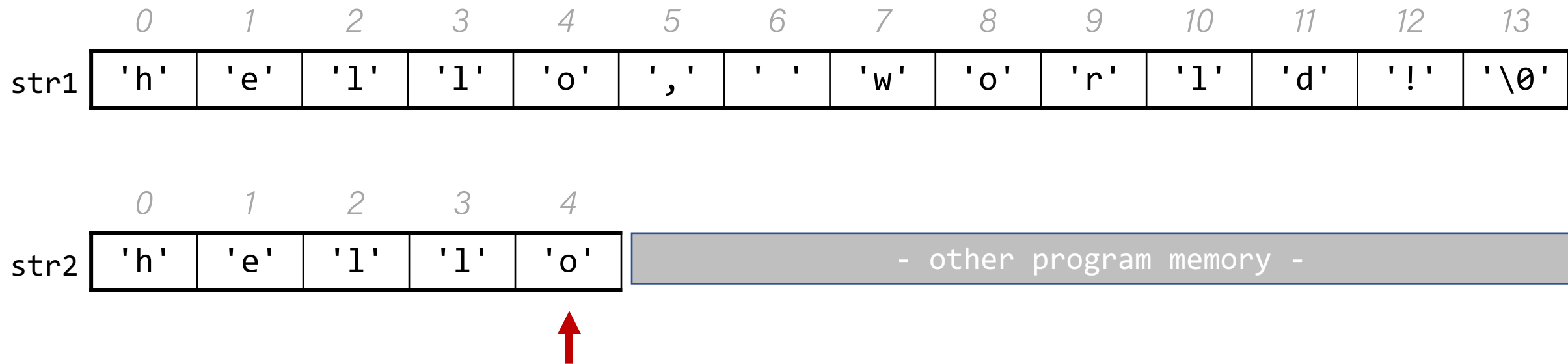
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



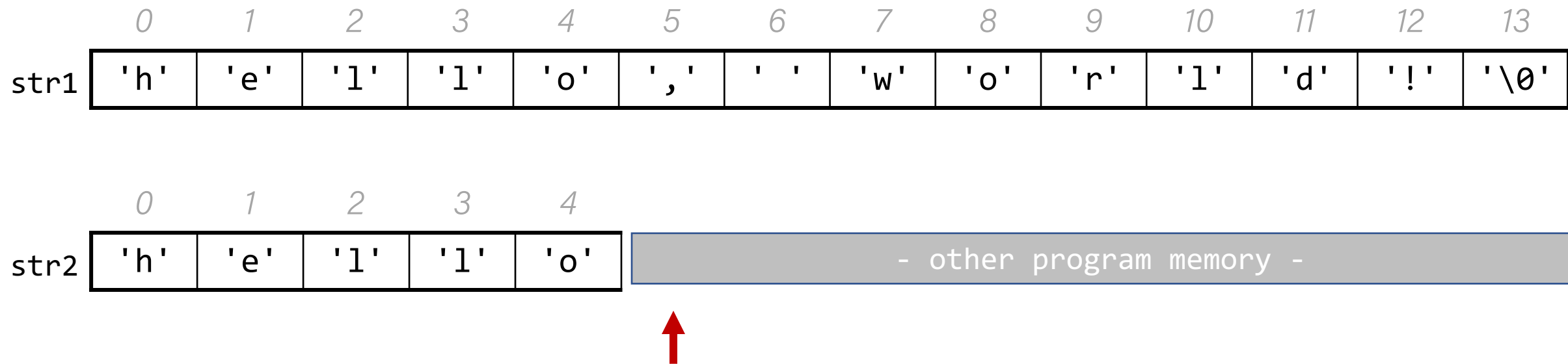
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



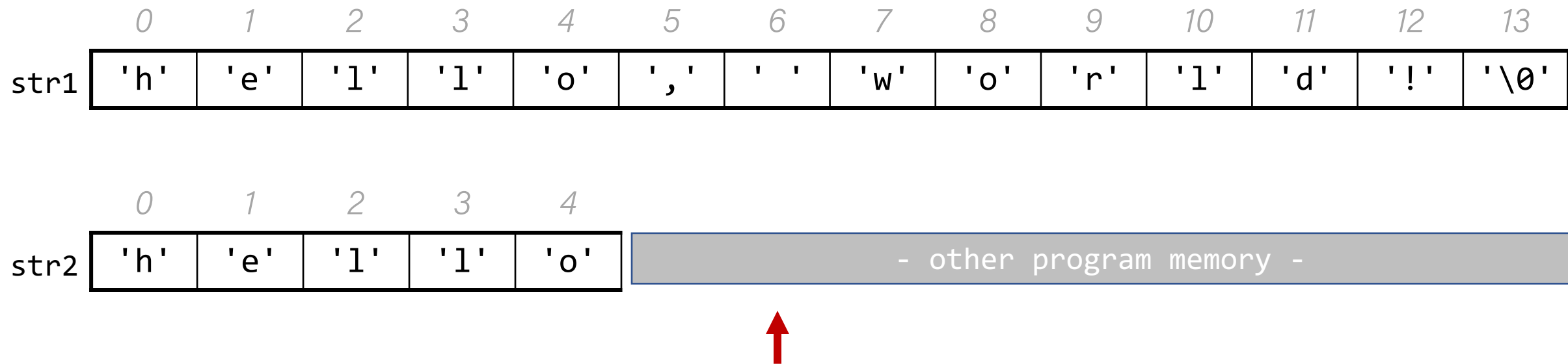
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



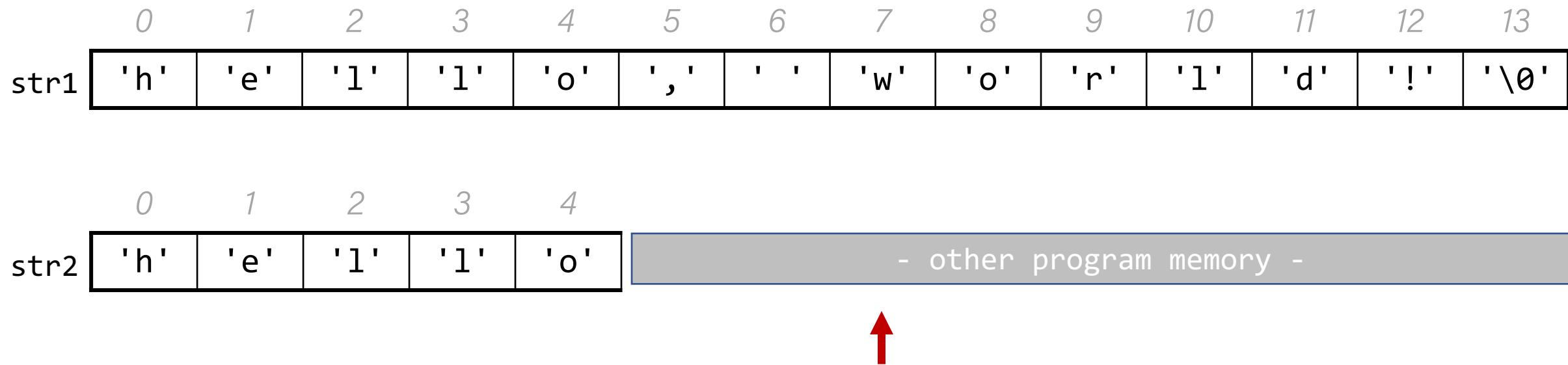
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



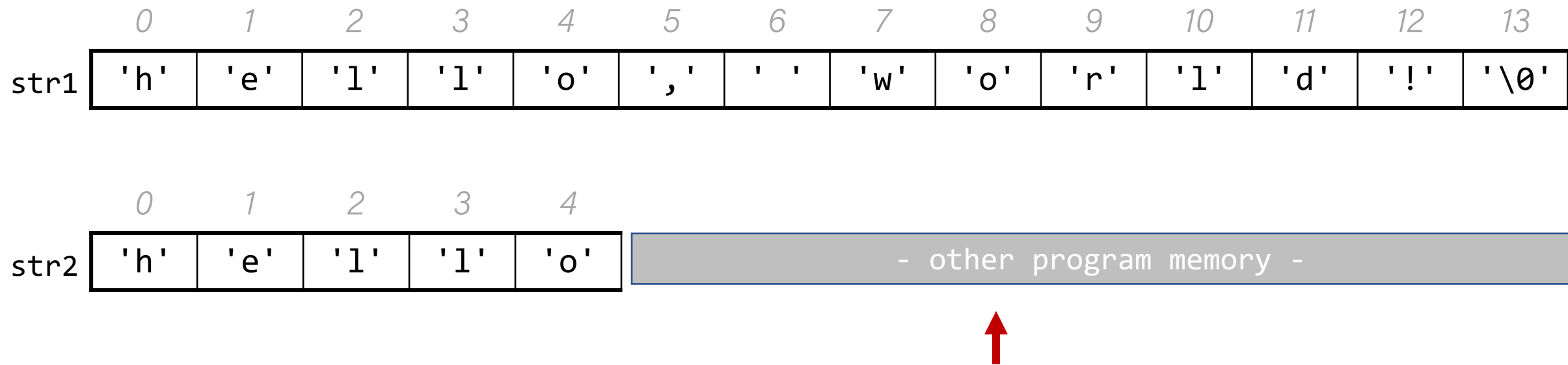
Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



Copying Strings – strncpy

```
char str2[5];  
strncpy(str2, "hello, world!", 5);  
int length = strlen(str2);
```



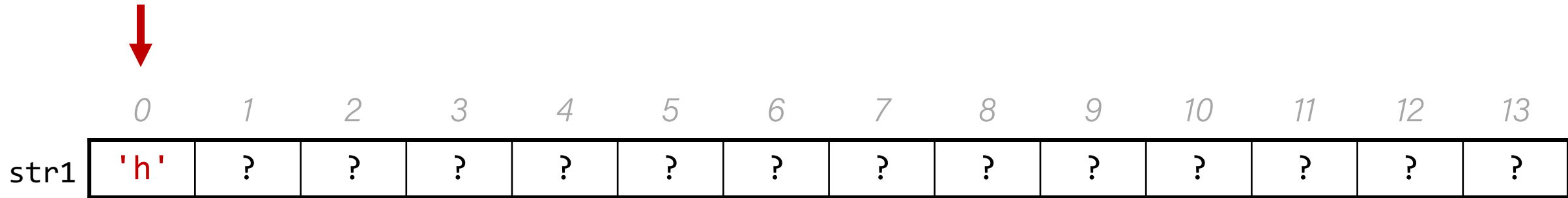
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
str1	?	?	?	?	?	?	?	?	?	?	?	?	?	?

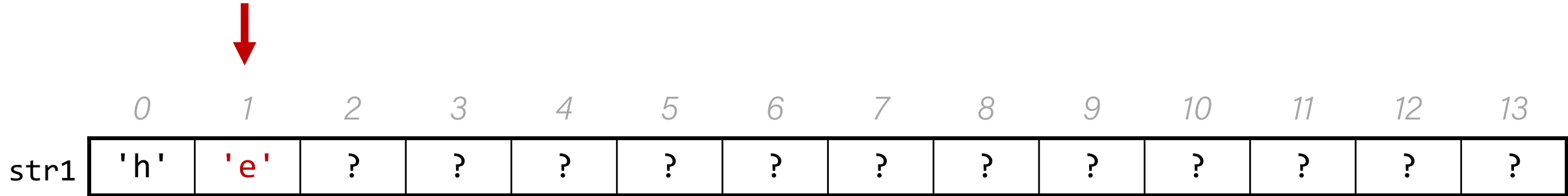
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```



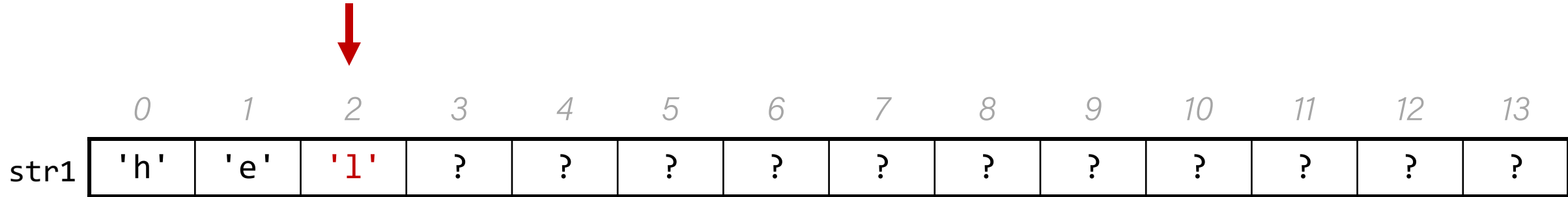
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```



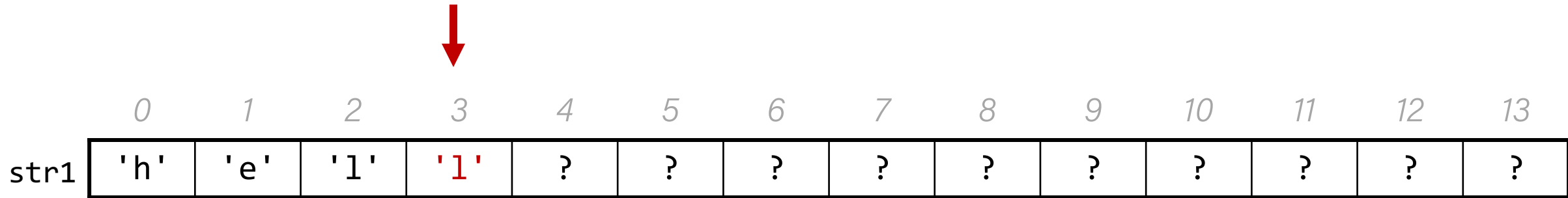
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```



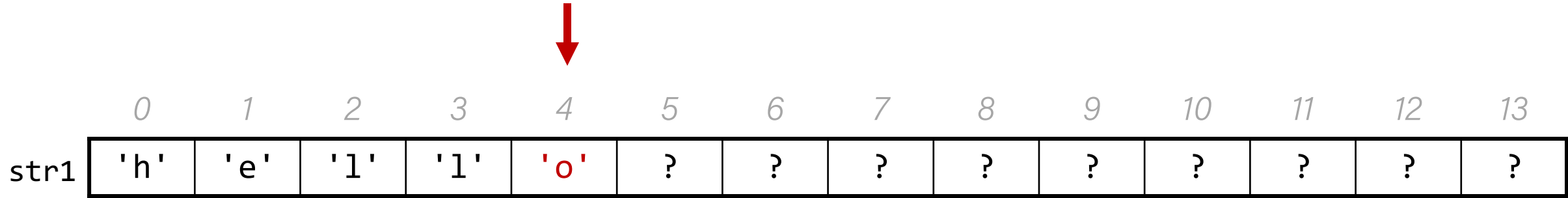
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```



Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```



Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);
```

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
str1	'h'	'e'	'l'	'l'	'o'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'

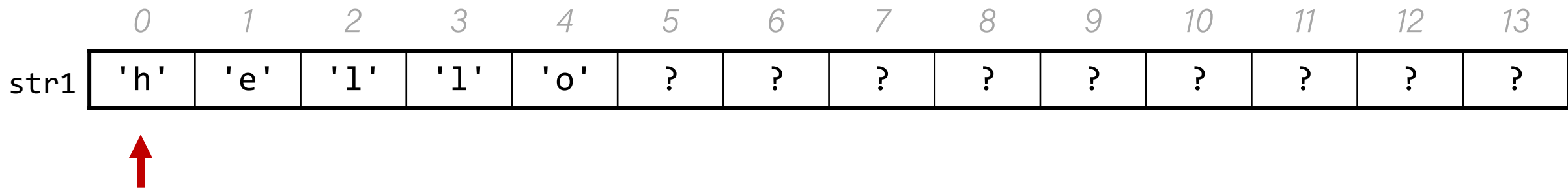
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
str1	'h'	'e'	'l'	'l'	'o'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'

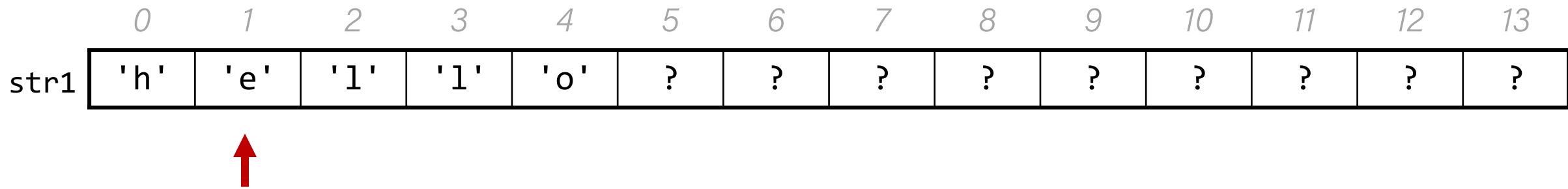
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



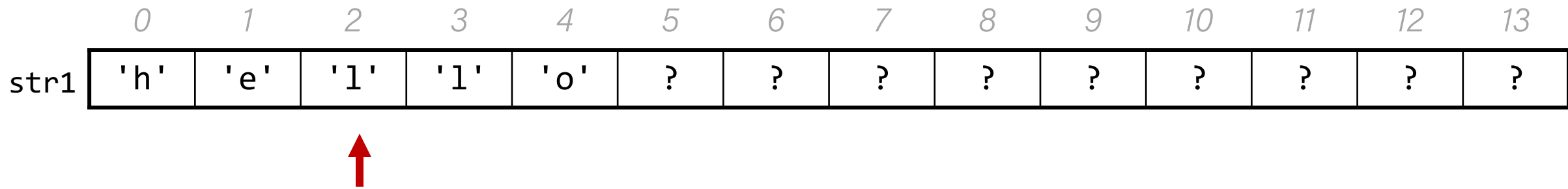
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



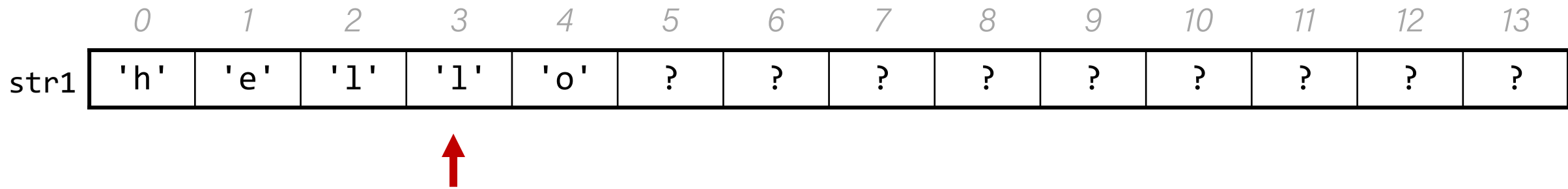
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



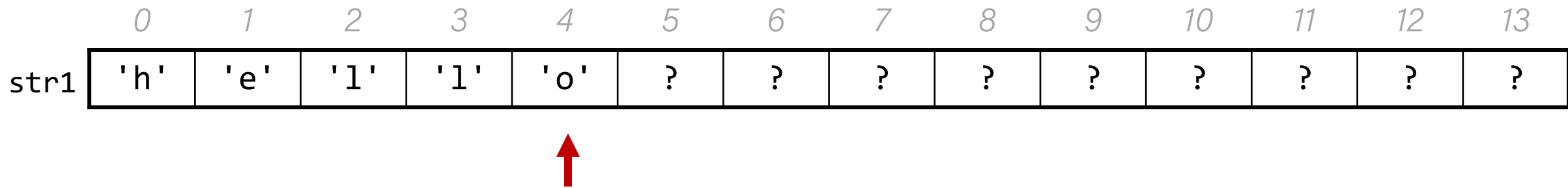
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



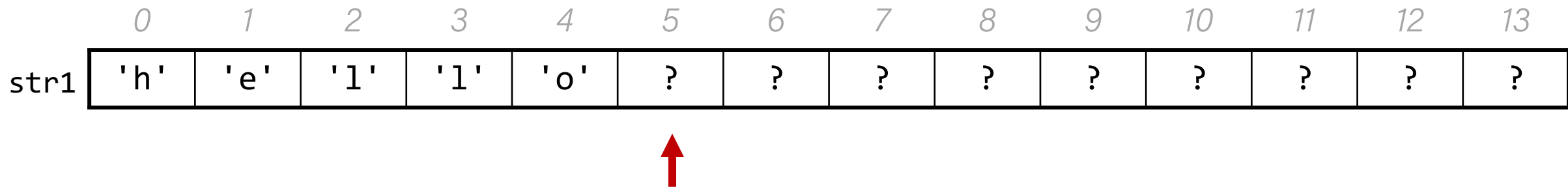
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



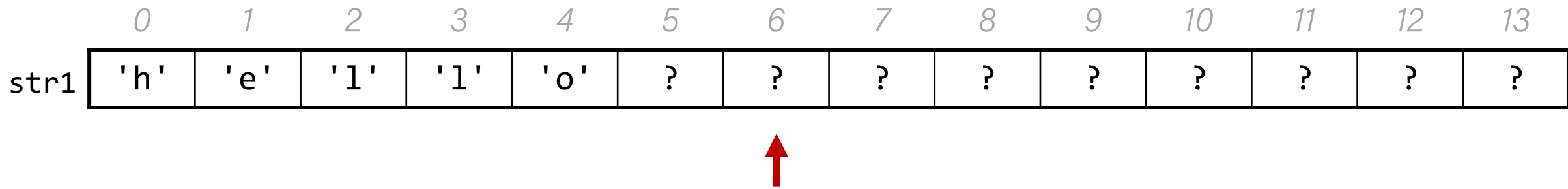
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



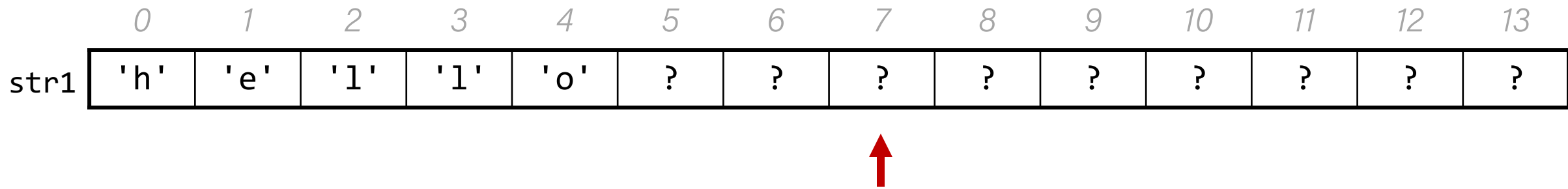
Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```



Copying Strings – strncpy

```
char str1[14];  
strncpy(str1, "hello there", 5);  
printf("%s\n", str1);
```

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
str1	'h'	'e'	'l'	'l'	'o'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'	'?'

hello[?][?]J[?][?][?]

Copying Strings – strncpy

If necessary, we can add a null-terminating character ourselves.

```
// copying "hello"
char str2[6]; // room for string and '\0'
strncpy(str2, "hello, world!", 5); // doesn't copy '\0'!
str2[5] = '\0'; // add null-terminating char
```

String copying exercise

```
1 char buf[      ];  
2 strcpy(buf, "Potatoes");  
3 printf("%s\n", buf);  
4 char *word = buf + 2;  
5 strncpy(word, "mat", 3);  
6 printf("%s\n", buf);
```

Line 1: What value should go in the blank?

- A. 7
- B. 8
- C. 9
- D. 12
- E. strlen("Potatoes")

Line 6: What is printed?

- A. matoes
- B. mattoes
- C. Pomat
- D. Pomatoes
- E. Something else
- F. Compile error



Concatenating Strings

We cannot concatenate C strings using `+`. This adds addresses!

```
// e.g. param1 = 0x7f, param2 = 0x65
void doSomething(char *param1, char *param2) {
    printf("%s", param1 + param2);    // adds 0x7f and 0x65!
```

Instead, use **strcat**.

The string library: `str(n)cat`

`strcat(dst, src)`: concatenates the contents of `src` into the string `dst`.

`strncat(dst, src, n)`: same, but concats at most `n` bytes from `src`.

```
char str1[13];           // enough space for strings + '\0'
strcpy(str1, "hello ");
strcat(str1, "world!");  // removes old '\0', adds new '\0' at end
printf("%s", str1);      // hello world!
```

Both **`strcat`** and **`strncat`** remove the old `'\0'` and add a new one at the end.

Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

```
strcat(str1, str2);
```

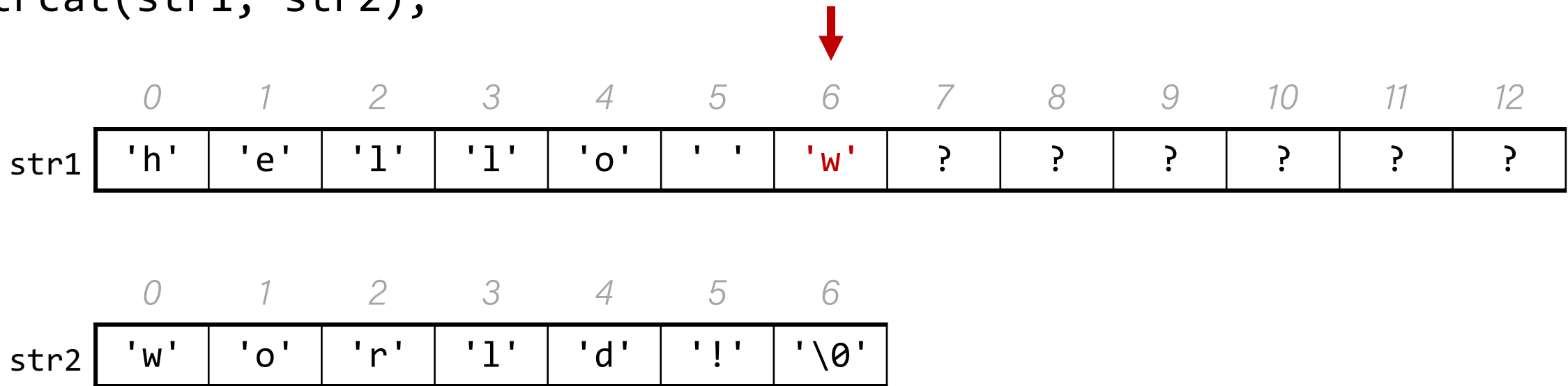
	0	1	2	3	4	5	6	7	8	9	10	11	12
str1	'h'	'e'	'l'	'l'	'o'	' '	'\0'	'?	'?	'?	'?	'?	'?

	0	1	2	3	4	5	6
str2	'w'	'o'	'r'	'l'	'd'	'!'	'\0'

Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

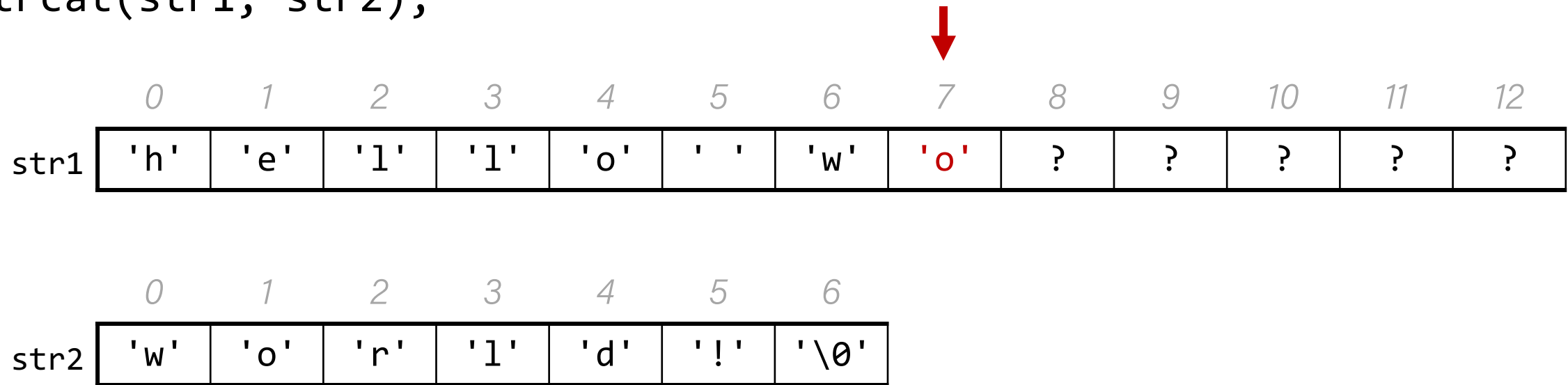
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

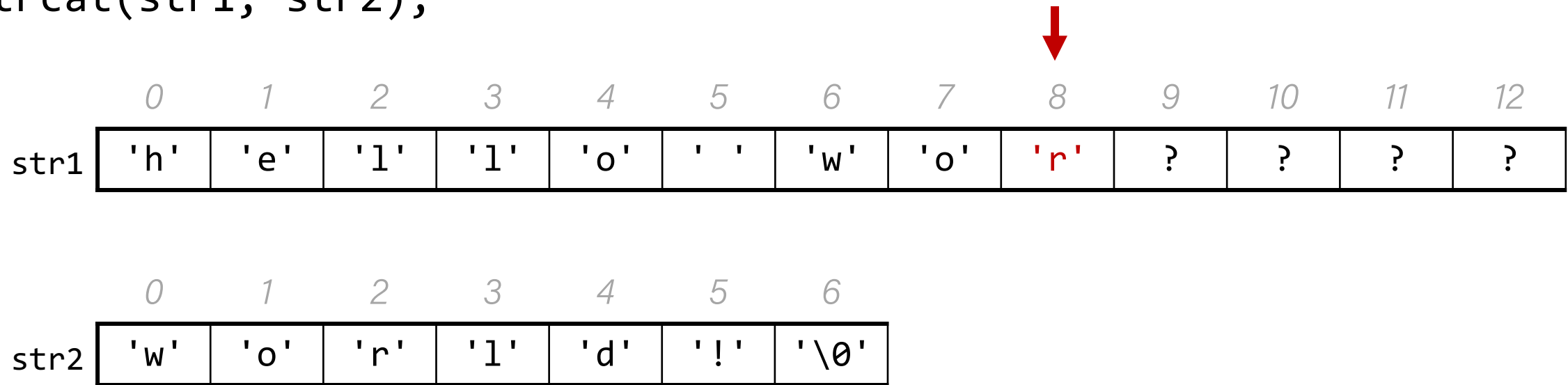
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

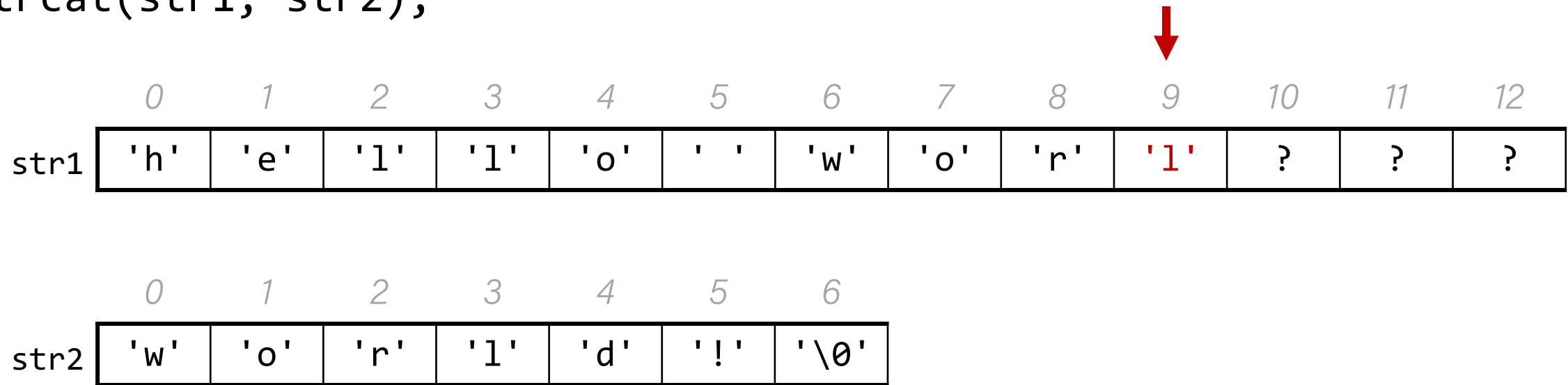
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

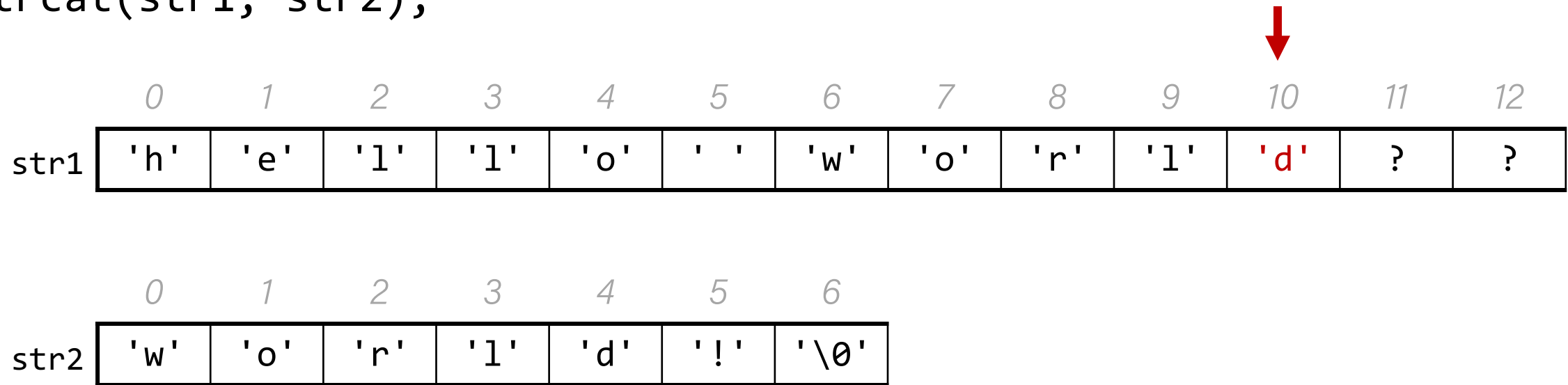
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

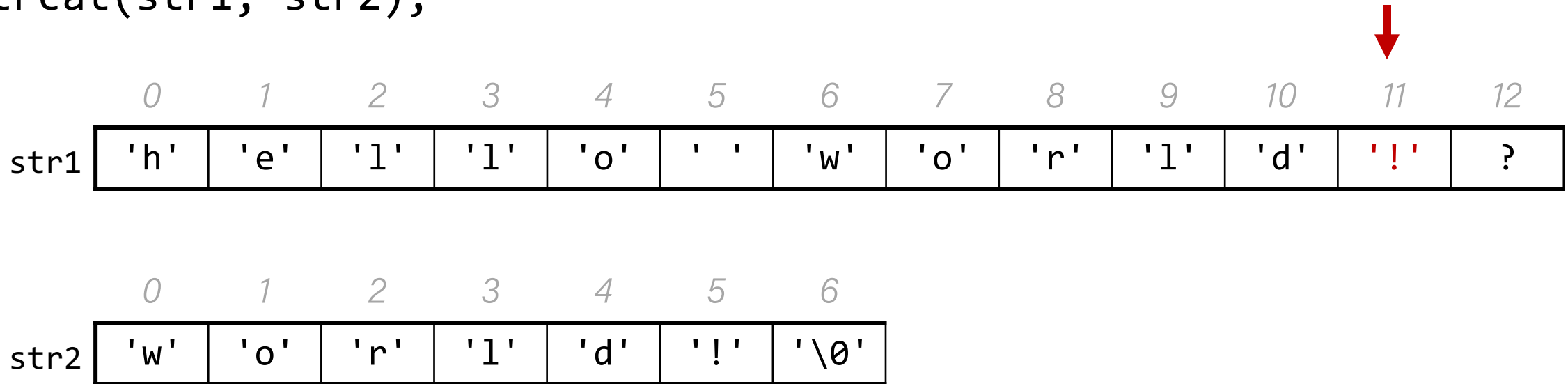
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

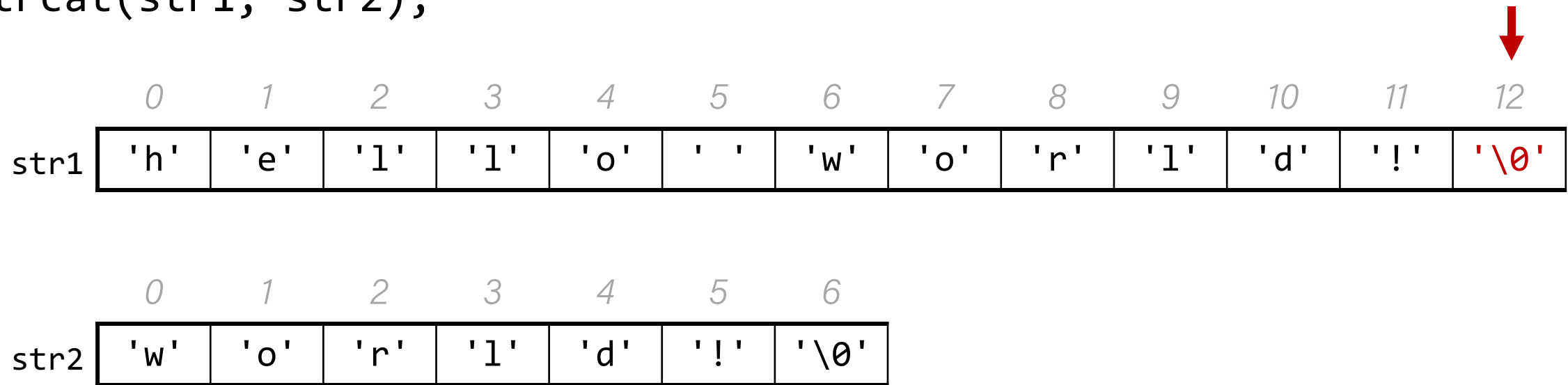
```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

```
strcat(str1, str2);
```



Concatenating Strings

```
char str1[13];  
strcpy(str1, "hello ");  
char str2[7];  
strcpy(str2, "world!");
```

```
strcat(str1, str2);
```

	0	1	2	3	4	5	6	7	8	9	10	11	12
str1	'h'	'e'	'l'	'l'	'o'	' '	'w'	'o'	'r'	'l'	'd'	'!'	'\0'

	0	1	2	3	4	5	6
str2	'w'	'o'	'r'	'l'	'd'	'!'	'\0'

Substrings and char *

You can also create a char * variable yourself that points to an address within in an existing string.

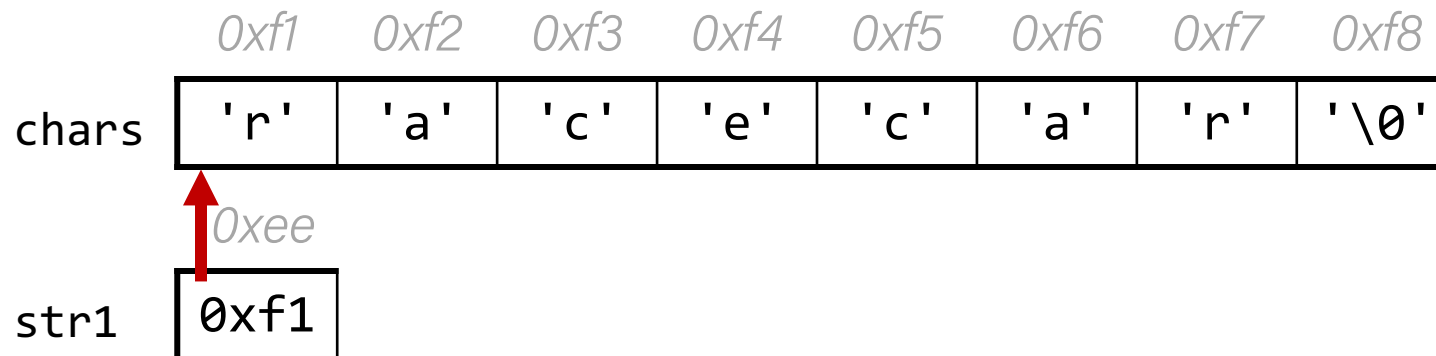
```
char myString[3];  
myString[0] = 'H';  
myString[1] = 'i';  
myString[2] = '\0';
```

```
char *otherStr = myString; // points to 'H'
```

Substrings

char *s are pointers to characters. We can use them to create substrings of larger strings.

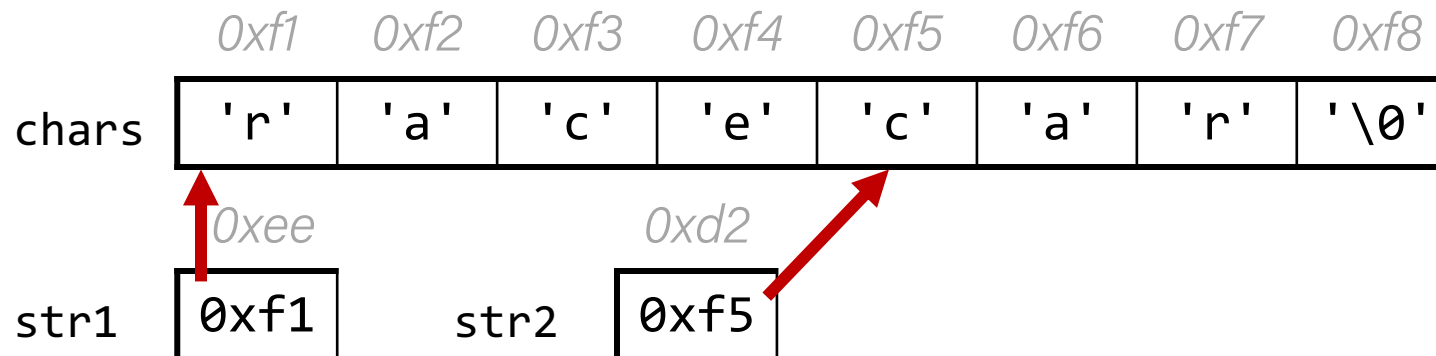
```
// Want just "car"  
char chars[8];  
strcpy(chars, "racecar");  
char *str1 = chars;
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning.

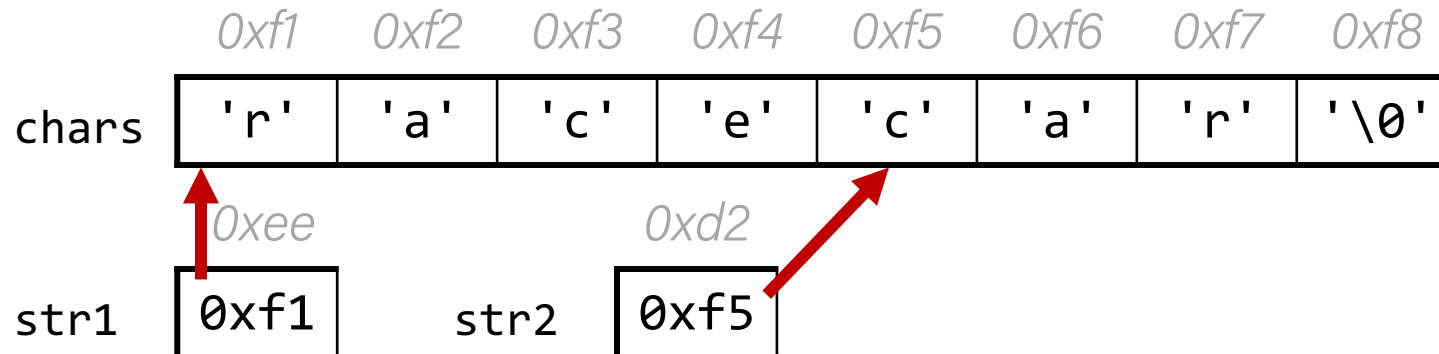
```
// Want just "car"  
char chars[8];  
strcpy(chars, "racecar");  
char *str1 = chars;  
char *str2 = chars + 4;
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning.

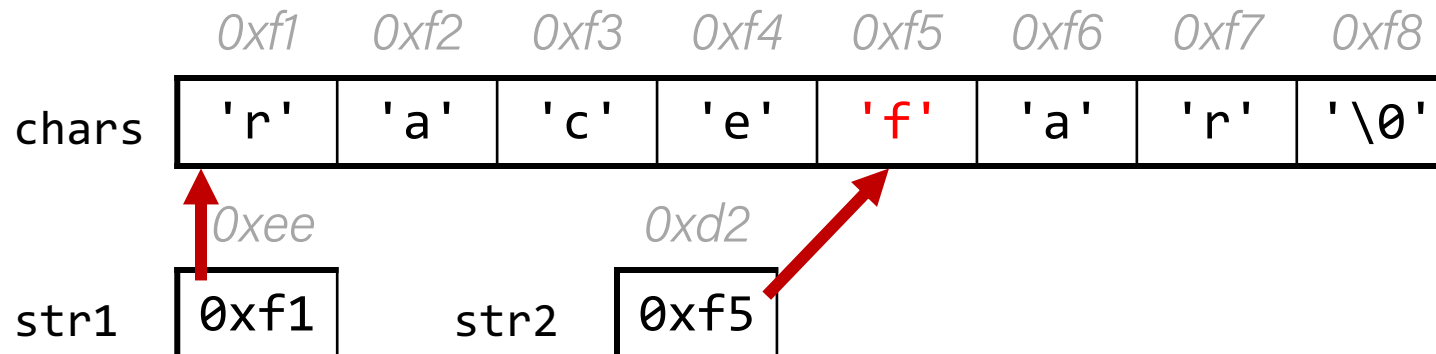
```
char chars[8];  
strcpy(chars, "racecar");  
char *str1 = chars;  
char *str2 = chars + 4;  
printf("%s\n", str1);           // racecar  
printf("%s\n", str2);           // car
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning. **NOTE:** the pointer still refers to the same characters!

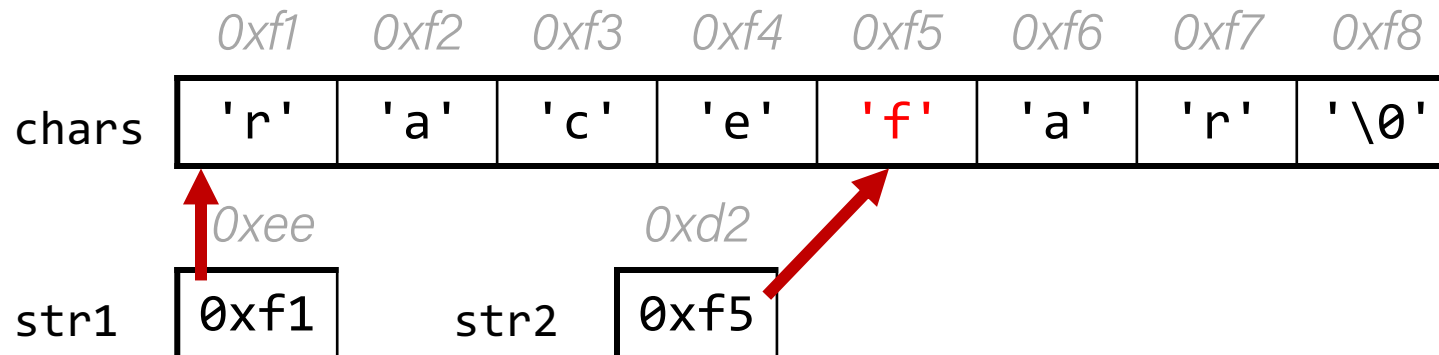
```
char chars[8];  
strcpy(chars, "racecar");  
char *str1 = chars;  
char *str2 = chars + 4;  
str2[0] = 'f';  
printf("%s %s\n", chars, str1);  
printf("%s\n", str2);
```



Substrings

Since C strings are pointers to characters, we can adjust the pointer to omit characters at the beginning. **NOTE:** the pointer still refers to the same characters!

```
char chars[8];  
strcpy(chars, "racecar");  
char *str1 = chars;  
char *str2 = chars + 4;  
str2[0] = 'f';  
printf("%s %s\n", chars, str1);           // racefar racefar  
printf("%s\n", str2);                     // far
```



char * vs. char[]

char myString[]

vs

char *myString

You can create char * pointers to point to any character in an existing string and reassign them since they are just pointer variables. You **cannot** reassign an array.

```
char myString[6];  
strcpy(myString, "Hello");  
myString = "Another string";  
---  
char *myOtherString = myString;  
myOtherString = somethingElse;
```

// not allowed!

// ok

Substrings

To omit characters at the end, make a new string that is a partial copy of the original.

```
// Want just "race"
char str1[8];
strcpy(str1, "racecar");

char str2[5];
strncpy(str2, str1, 4);
str2[4] = '\0';
printf("%s\n", str1);           // racecar
printf("%s\n", str2);          // race
```

Substrings

We can combine pointer arithmetic and copying to make any substrings we'd like.

```
// Want just "ace"
char str1[8];
strcpy(str1, "racecar");

char str2[4];
strncpy(str2, str1 + 1, 3);
str2[3] = '\0';
printf("%s\n", str1);           // racecar
printf("%s\n", str2);          // ace
```

Recap

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

String Diamond

- Write a function **diamond** that accepts a string parameter and prints its letters in a "diamond" format as shown below.
 - For example, `diamond("COMP201")` should print:

```
C
CO
COM
COMP
COMP2
COMP20
COMP201
OMP201
MP201
P201
201
01
1
```

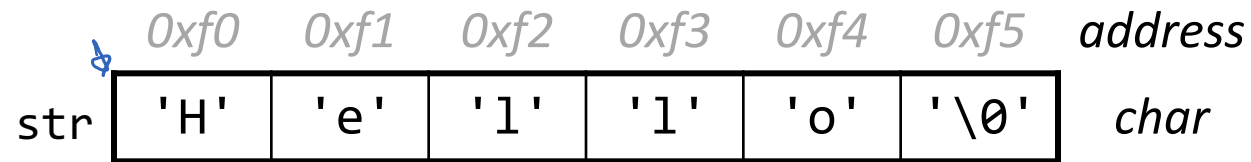
Practice: Diamond



diamond.c

Key takeaways

1. Valid strings are null-terminated.

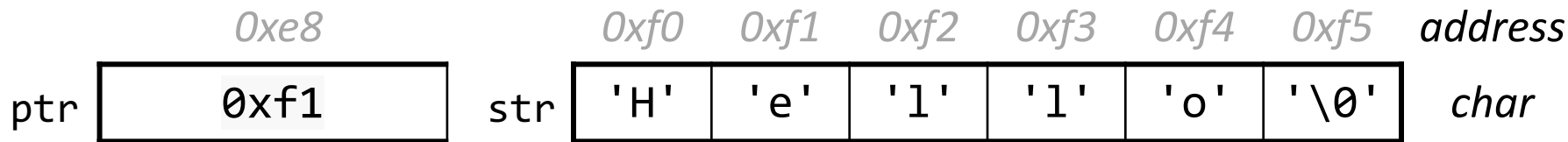


```
char str[6];  
strcpy(str, "Hello");  
int length = strlen(str); // 5
```

Blue arrows point from the 'str' variable in the code to the first cell of the memory diagram, and from the 'length' variable to the value '5'.

Key takeaways from this time

1. Valid strings are null-terminated.
2. An array name (and a string name, by extension) is the address of the first element.



```
char str[6];
strcpy(str, "Hello");
int length = strlen(str); // 5
char *ptr = str + 1;      // 0xf1
printf("%s\n", ptr);      // ello
```

Key takeaways from this time

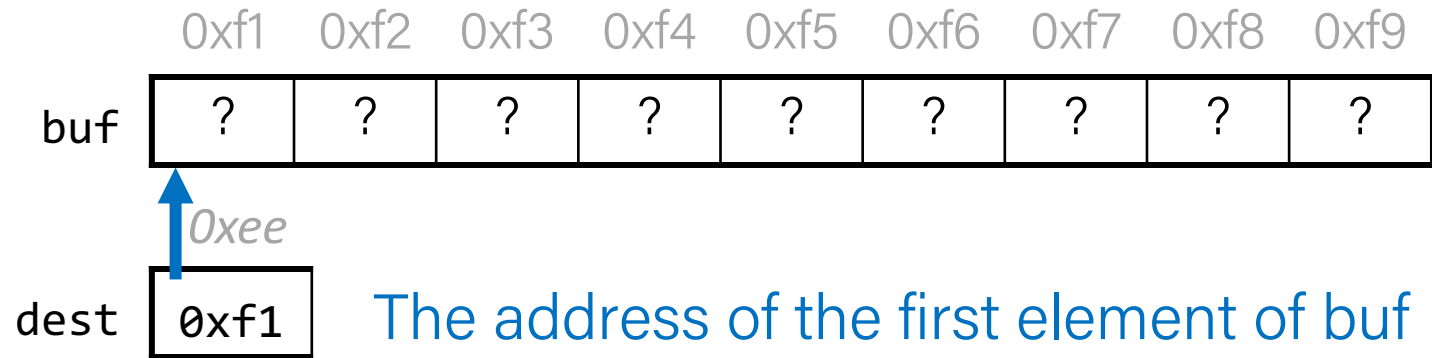
1. Valid strings are null-terminated.
2. An array name (and a string name, by extension) is the address of the first element.
3. When you pass a `char[]` as a parameter, it is automatically passed as a `char *` (pointer to its first character)

Why did C bother with this representation?

- C is a powerful, **efficient** language that requires a solid understanding of computer memory.
- We'll hone this understanding over these next two weeks!

Takeaway #3 : man strcpy

```
1 char buf[6];
2 strcpy(buf, "Hello");
3 printf("%s\n", buf);
... ..
```



STRCPY(3)

Linux Programmer's Manual

NAME

strcpy, strncpy – copy a string

SYNOPSIS

#include <string.h>

char *strcpy(char *dest, const char *src);

- Lecture 6: where string constants like "hello" are stored.
- Lecture 11: what const means

Recap

- Characters
- Strings
- Common String Operations
- Practice: Diamonds

Next time: More strings