CS107, Lecture 4
C Strings

Reading: K&R (1.9, 5.5, Appendix B3) or Essential C section 3

This document is copyright (C) Stanford Computer Science and Nick Troccoli, licensed under Creative Commons Attribution 2.5 License. All rights reserved.
Based on slides created by Marty Stepp, Cynthia Lee, Chris Gregg, Lisa Yan, Jerry Cain and others.

CS107 Topic 2: How can a computer represent and manipulate more complex data like text?

Lecture Plan

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

Lecture Plan

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

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 *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!)

```
char uppercaseA = 'A';          // Actually 65
char lowercaseA = 'a';          // Actually 97
char zeroDigit = '0';           // Actually 48
```

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(`***ch***`)`	true if *ch* is `'a'` through `'z'` or `'A'` through `'Z'`
`islower(`***ch***`)`	true if *ch* is `'a'` through `'z'`
`isupper(`***ch***`)`	true if *ch* is `'A'` through `'Z'`
`isspace(`***ch***`)`	true if *ch* is a space, tab, new line, etc.
`isdigit(`***ch***`)`	true if *ch* is `'0'` through `'9'`
`toupper(`***ch***`)`	returns uppercase equivalent of a letter
`tolower(`***ch***`)`	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

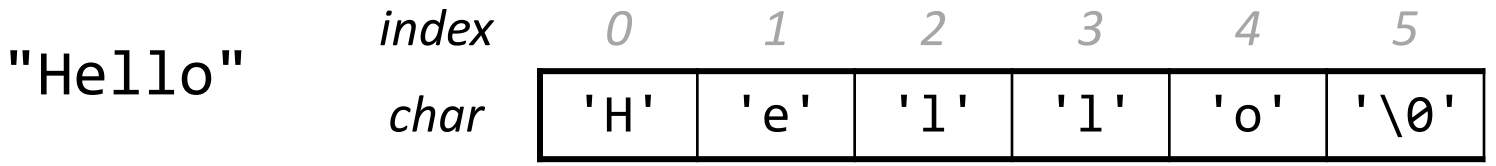
```
bool isLetter = isalpha('A');       // true
bool capital = isupper('f');        // false
char uppercaseB = toupper('b');
bool isADigit = isdigit('4');       // true
```

Lecture Plan

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

C Strings

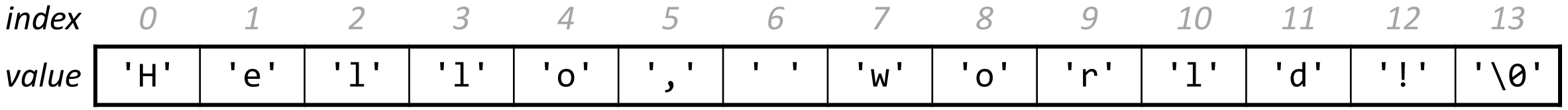
C has no dedicated variable type for strings. Instead, a string is represented as an **array of characters** with a special ending sentinel value.



`'\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!



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**: Diamond

Common `string.h` Functions

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

Common `string.h` Functions

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

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`**.

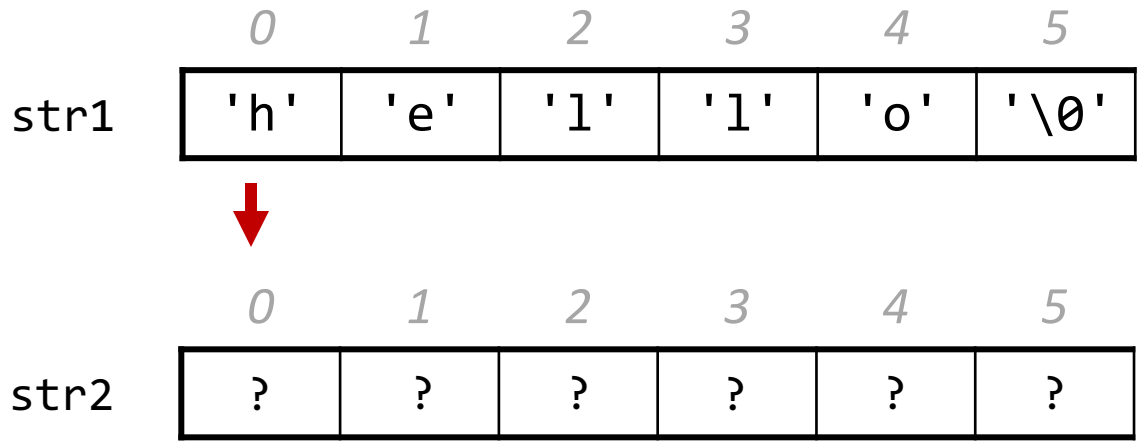
The string library: `strcpy`

`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`

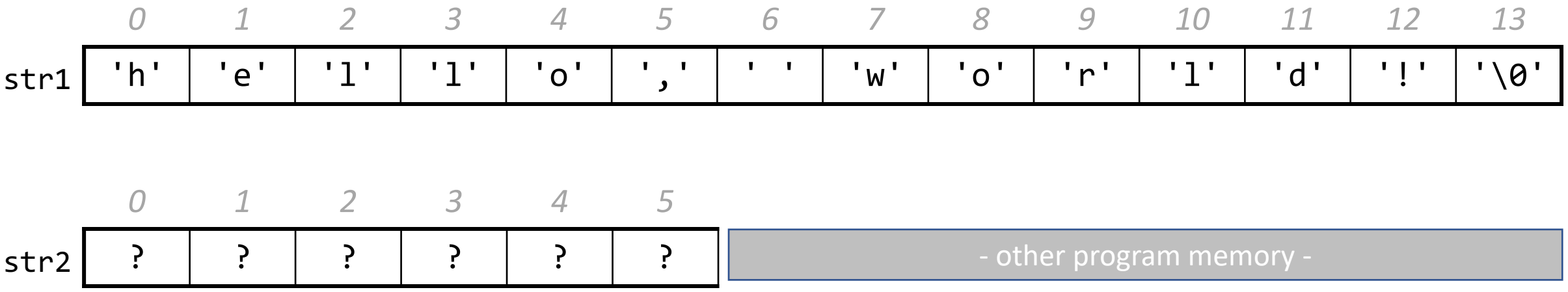
We must make sure there is enough space in the destination to hold the entire copy, *including the null-terminating character*.

```
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!

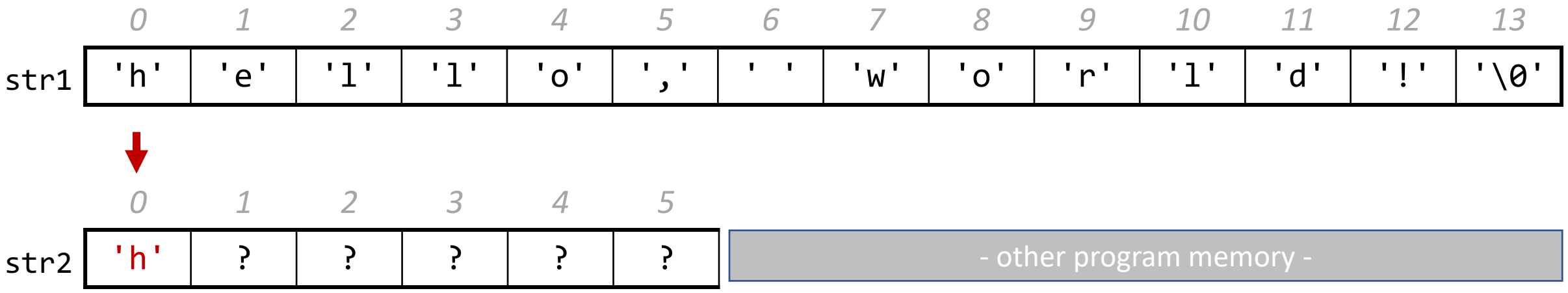
Copying Strings – Buffer Overflows

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



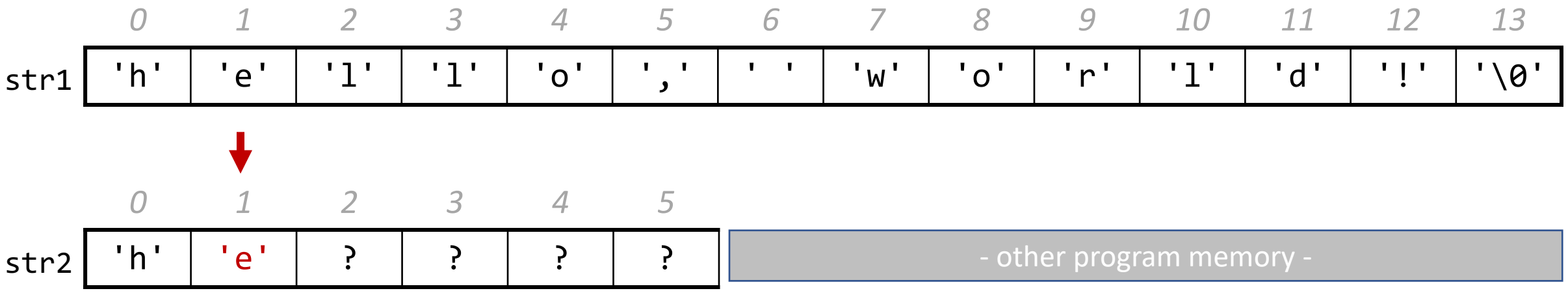
Copying Strings – Buffer Overflows

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



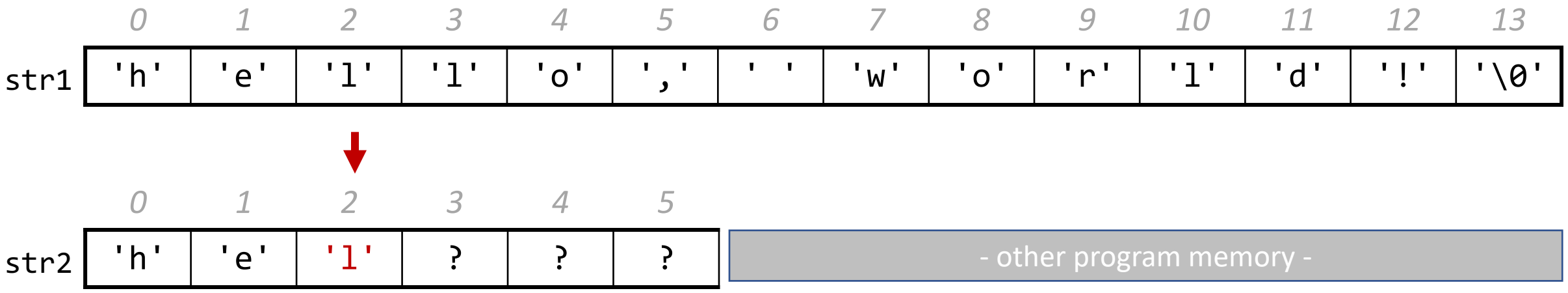
Copying Strings – Buffer Overflows

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



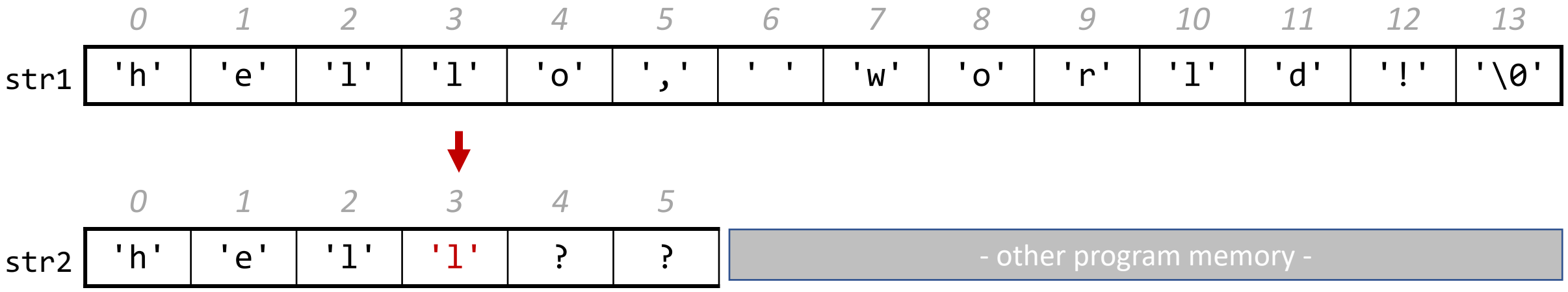
Copying Strings – Buffer Overflows

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



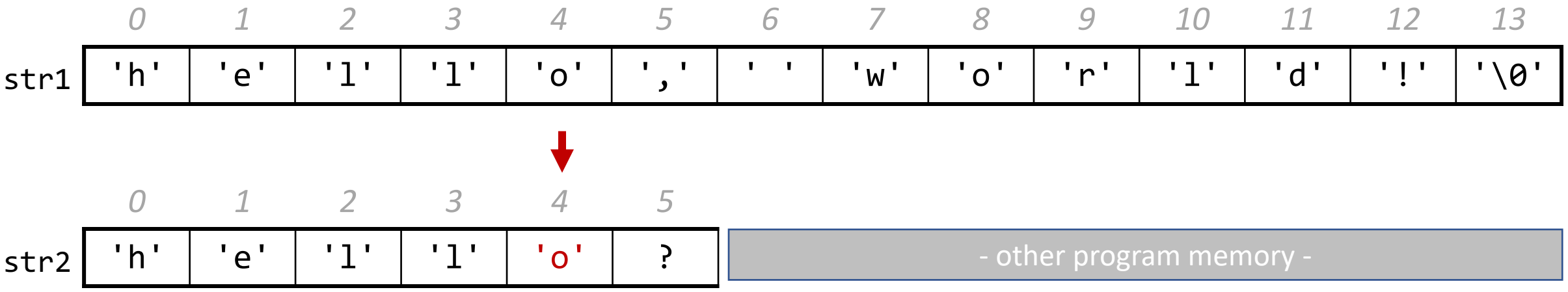
Copying Strings – Buffer Overflows

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



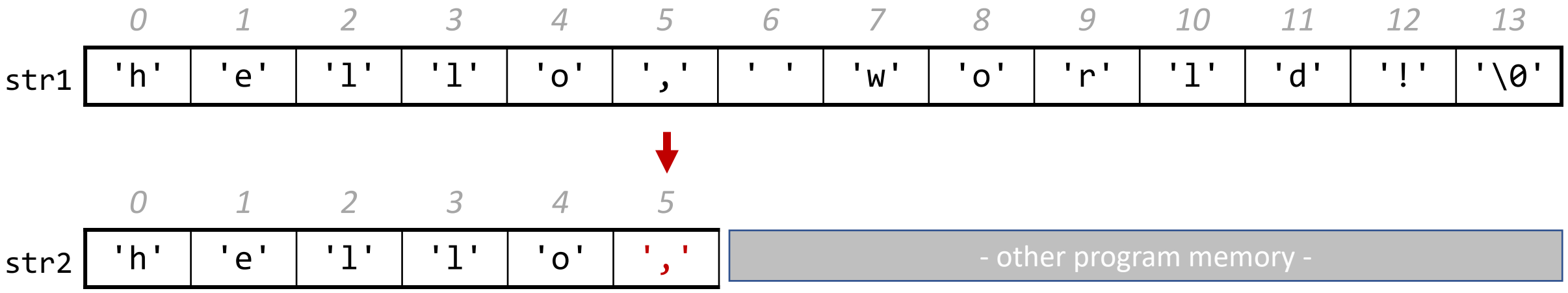
Copying Strings – Buffer Overflows

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



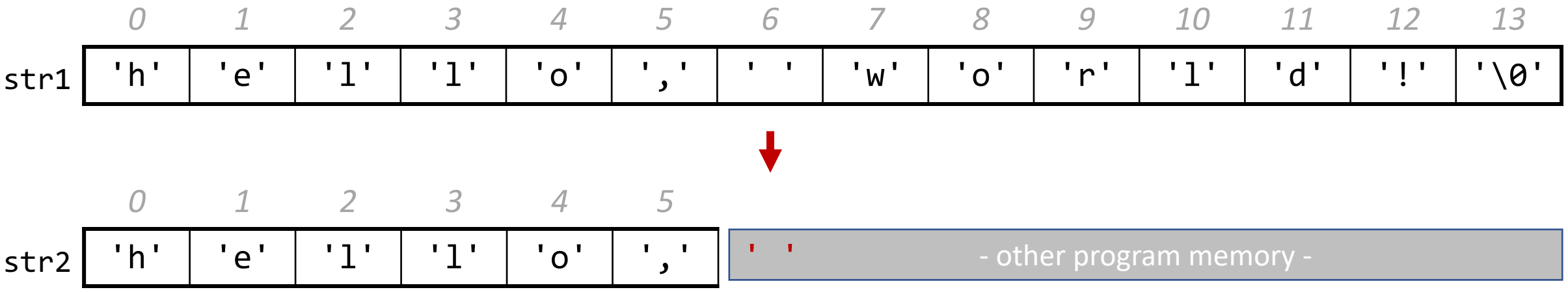
Copying Strings – Buffer Overflows

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



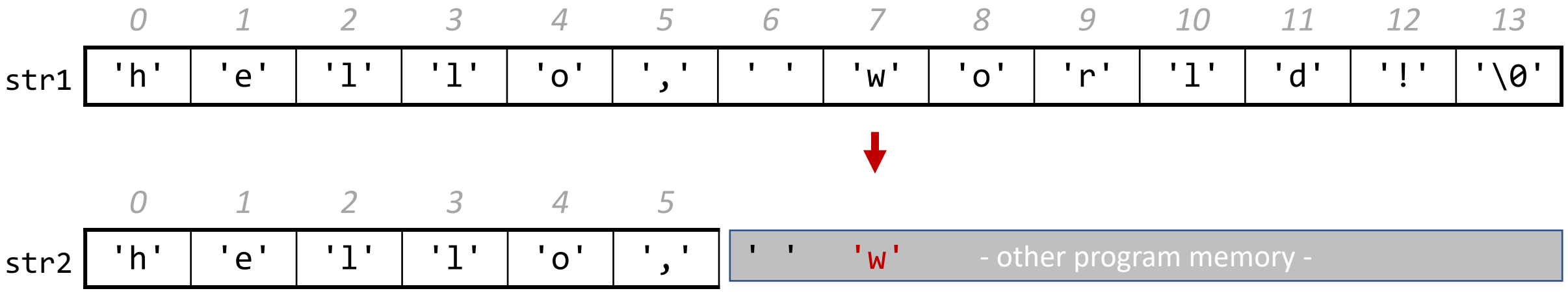
Copying Strings – Buffer Overflows

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



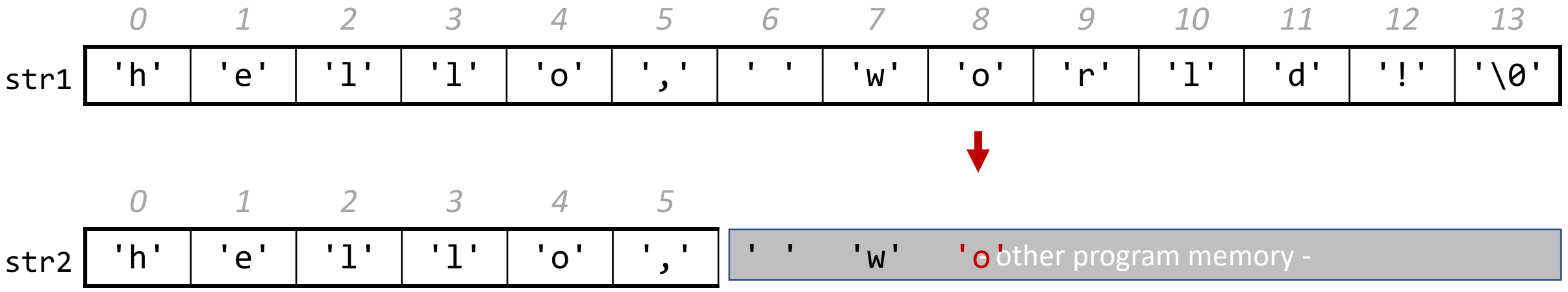
Copying Strings – Buffer Overflows

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



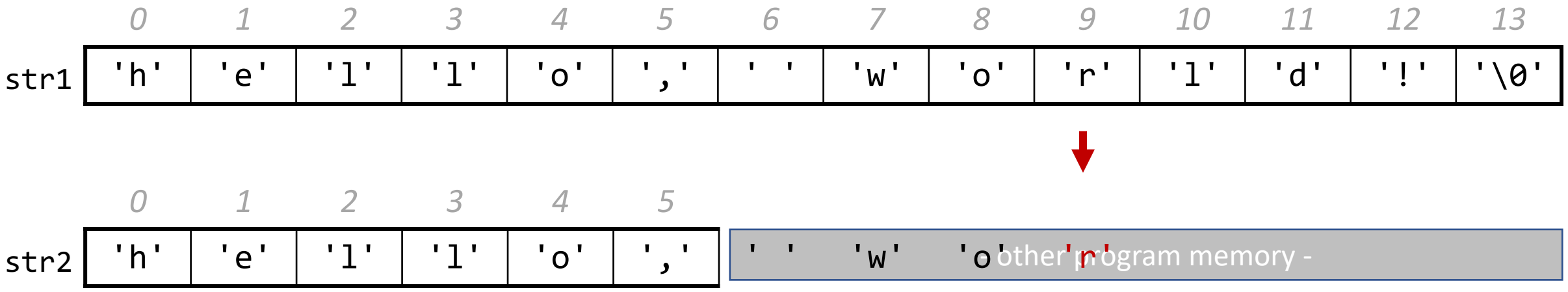
Copying Strings – Buffer Overflows

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



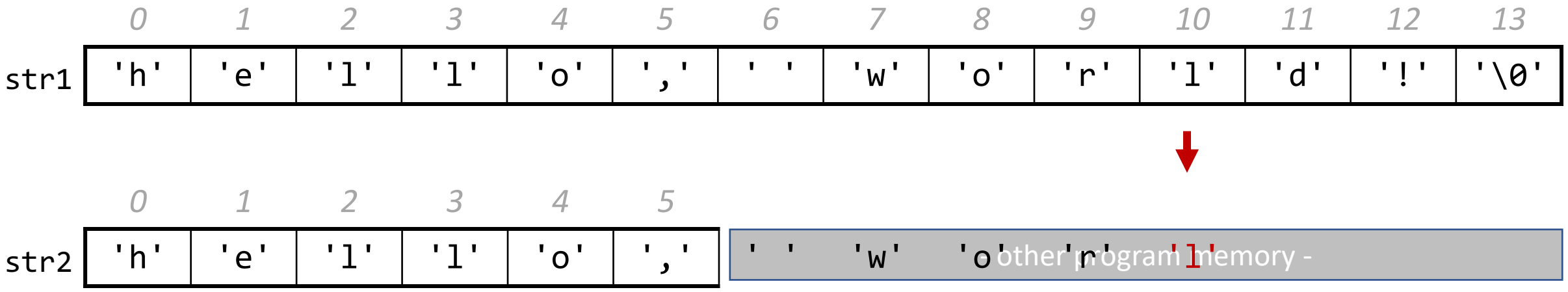
Copying Strings – Buffer Overflows

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



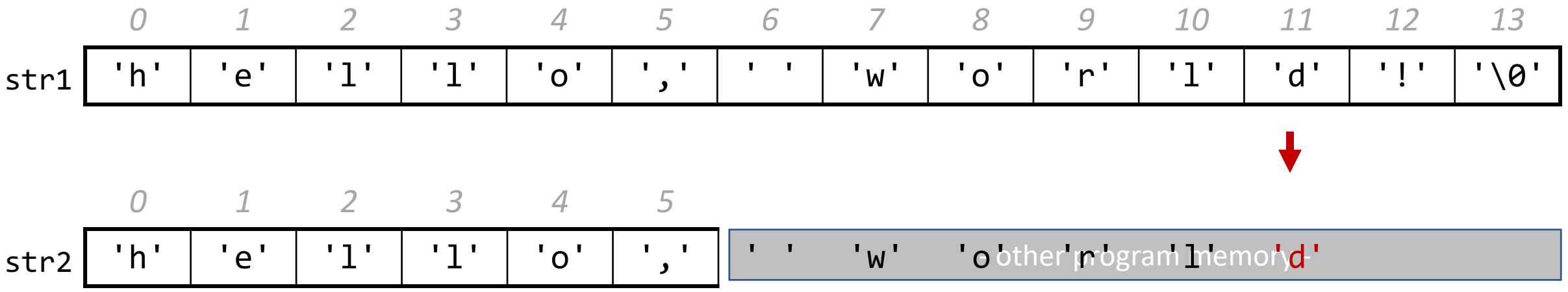
Copying Strings – Buffer Overflows

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



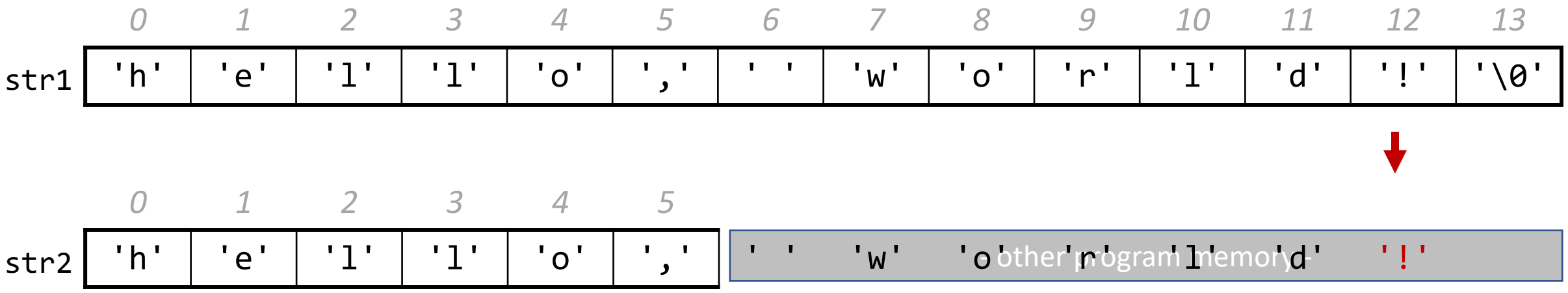
Copying Strings – Buffer Overflows

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



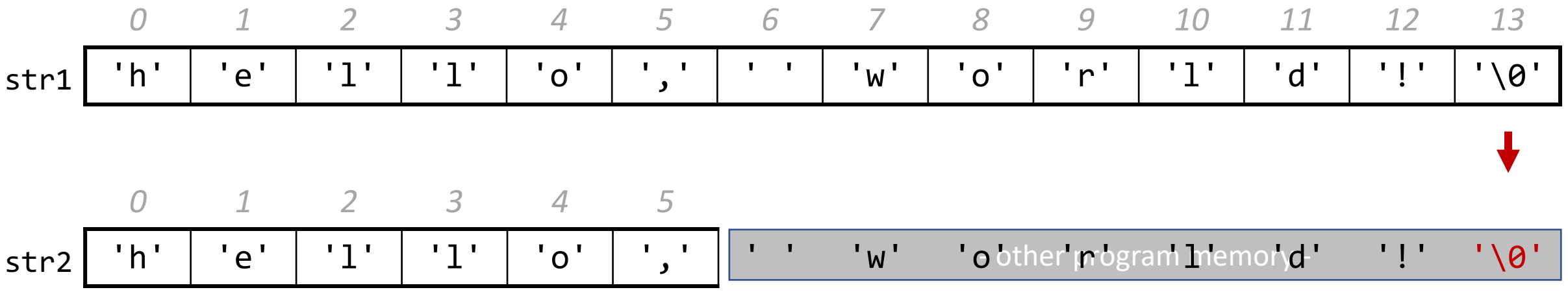
Copying Strings – Buffer Overflows

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



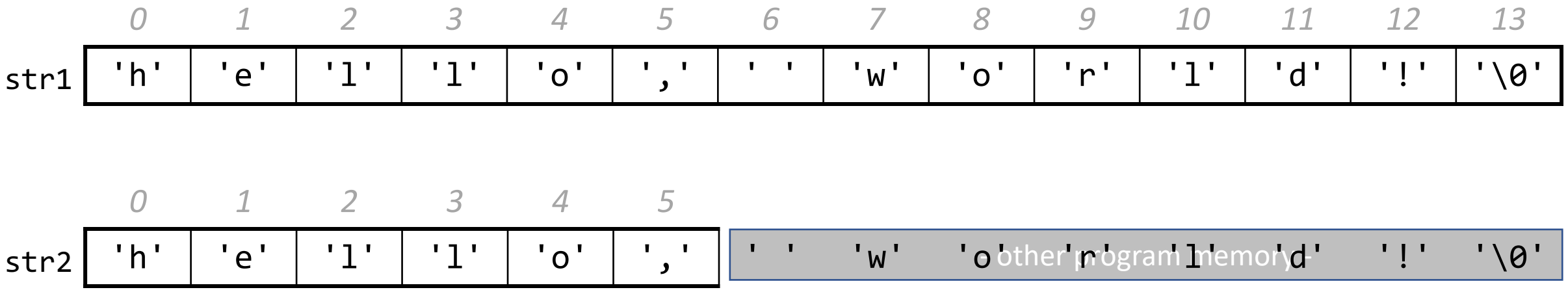
Copying Strings – Buffer Overflows

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



Copying Strings – Buffer Overflows

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



Copying Strings - `strncpy`

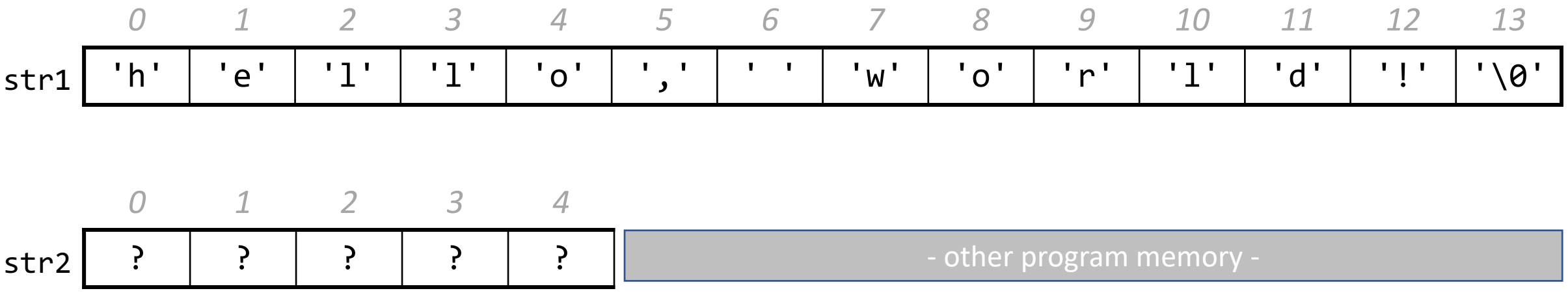
`strncpy(dst, src, n)`: copies at most the first n bytes from **src** into the string **dst**. If there is no null-terminating character in these bytes, then **`dst`** will *not be null terminated*!

```
// 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'`!

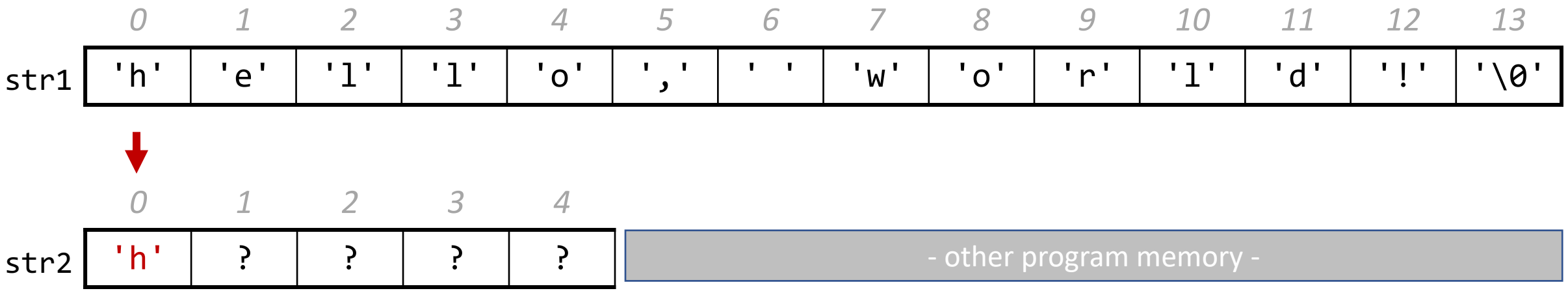
Copying Strings - strncpy

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



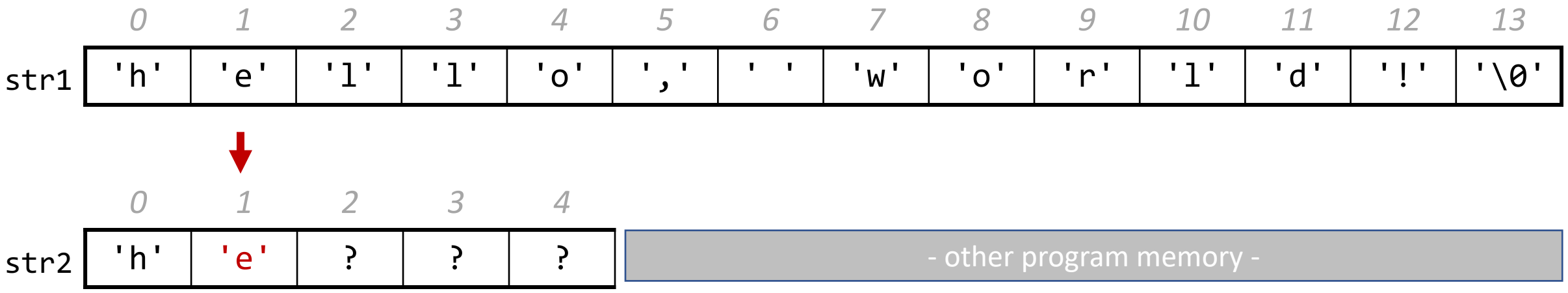
Copying Strings - strncpy

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



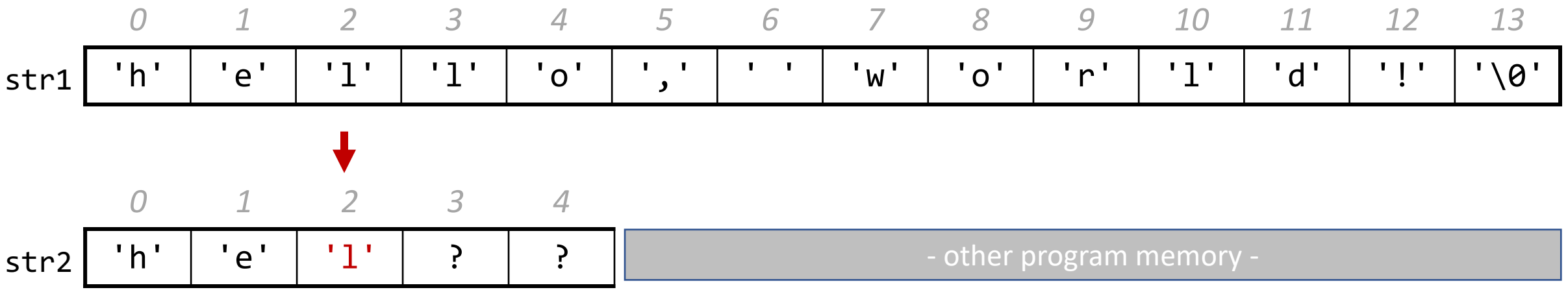
Copying Strings - strncpy

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



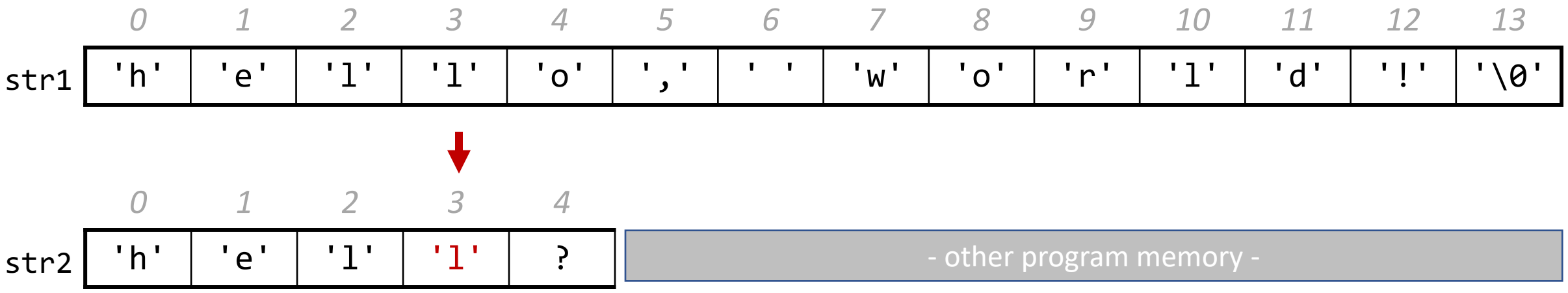
Copying Strings - strncpy

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



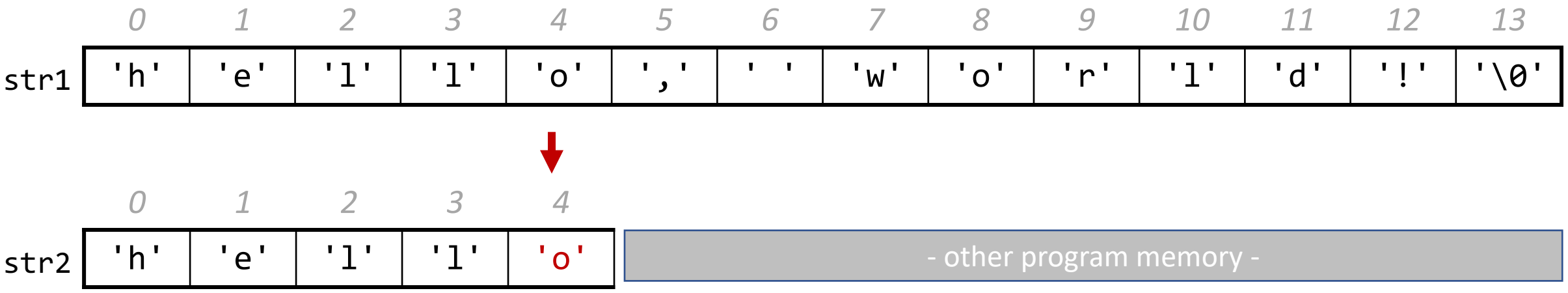
Copying Strings - strncpy

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



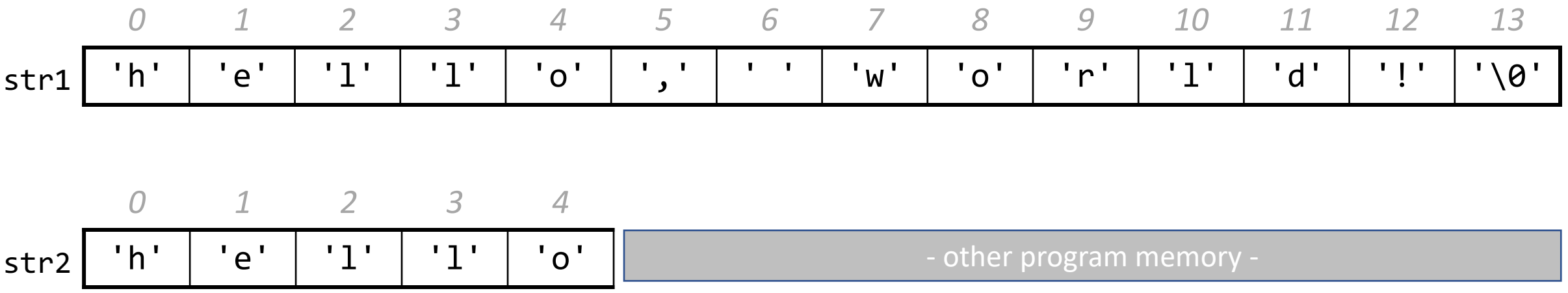
Copying Strings - strncpy

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



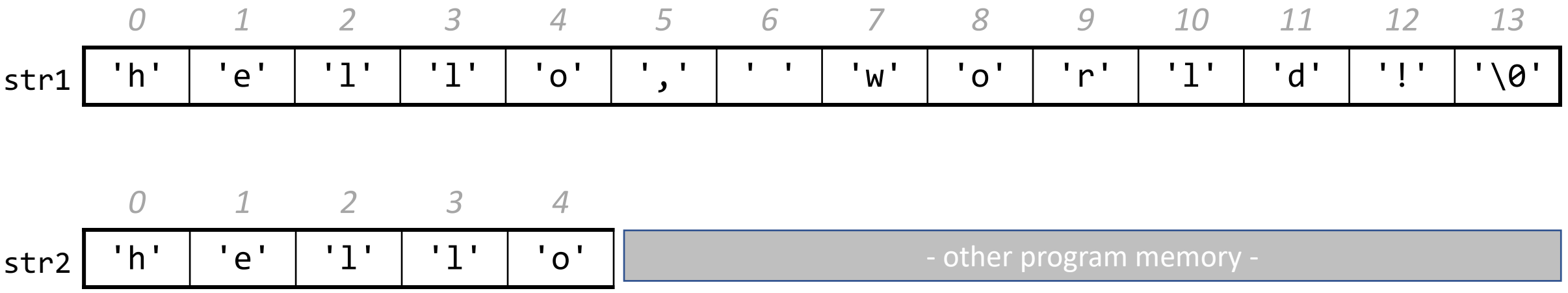
Copying Strings - strncpy

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



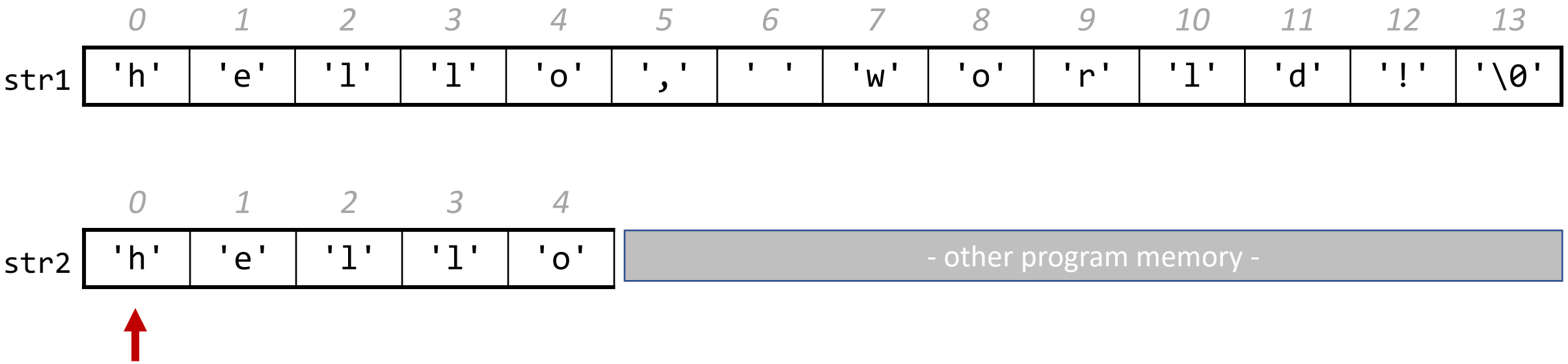
Copying Strings - strncpy

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



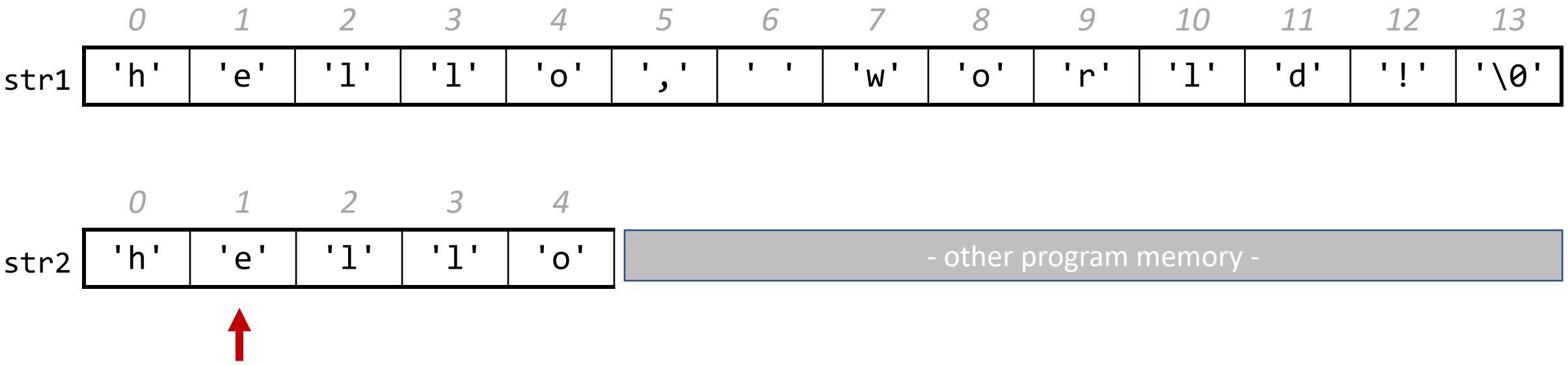
Copying Strings - strncpy

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



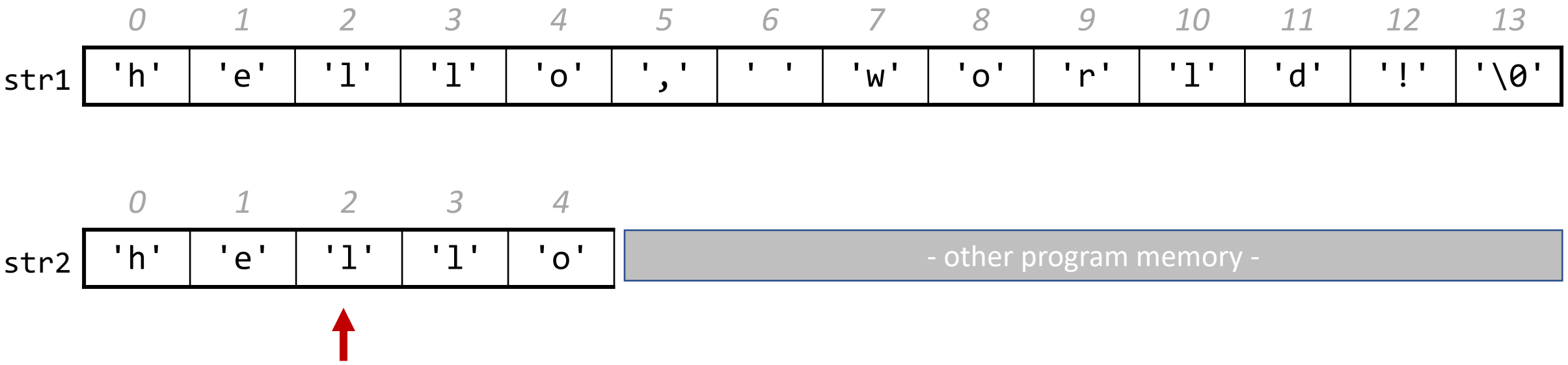
Copying Strings - strncpy

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



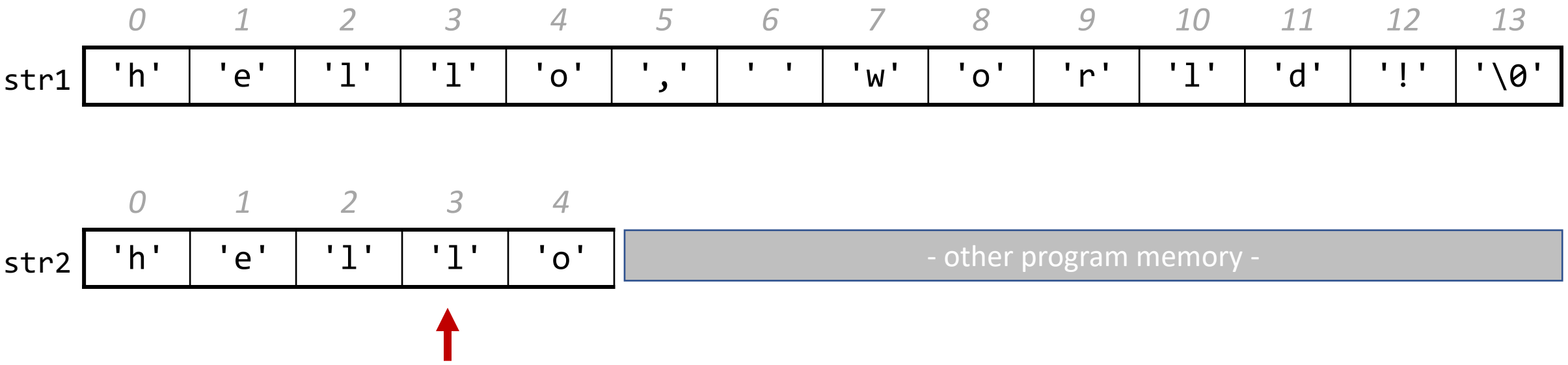
Copying Strings - strncpy

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



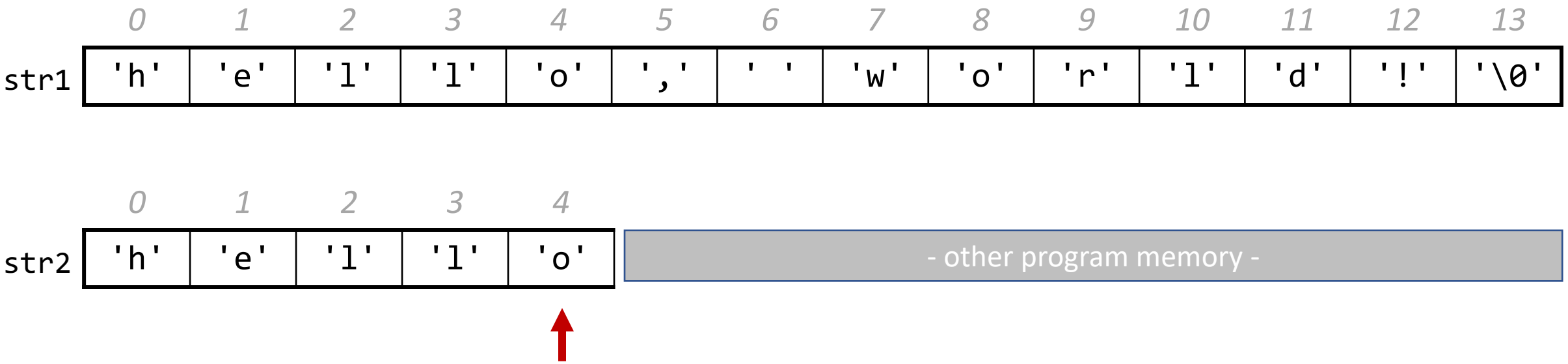
Copying Strings - strncpy

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



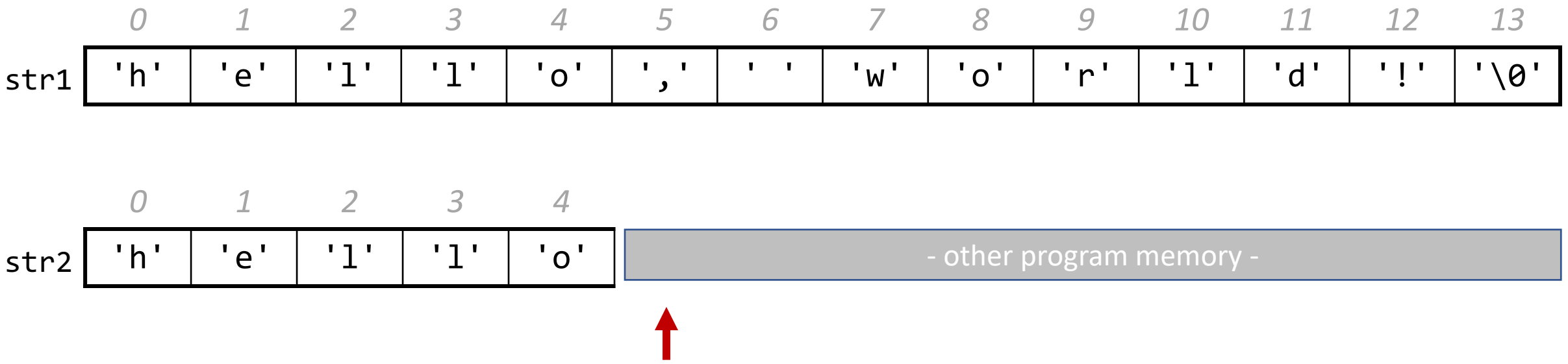
Copying Strings - strncpy

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



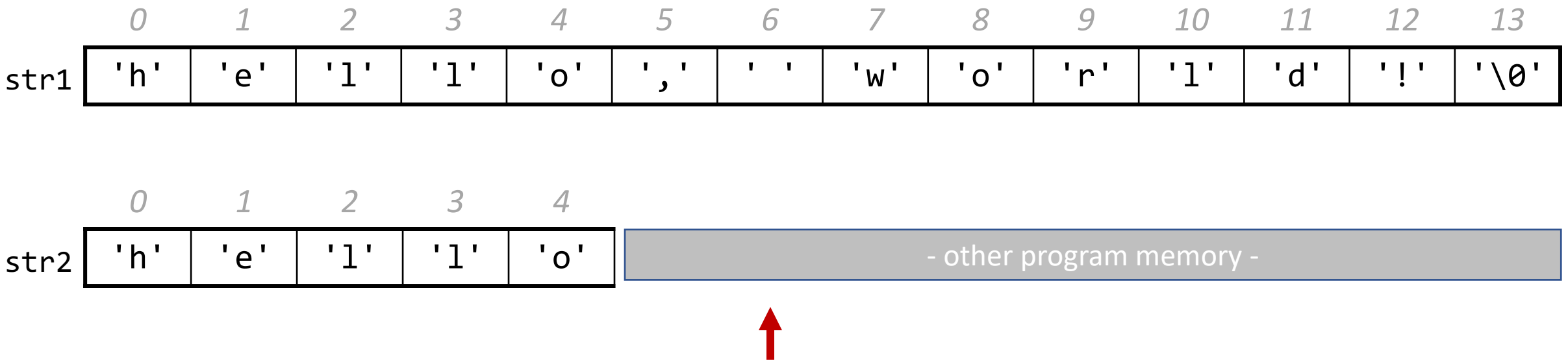
Copying Strings - strncpy

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



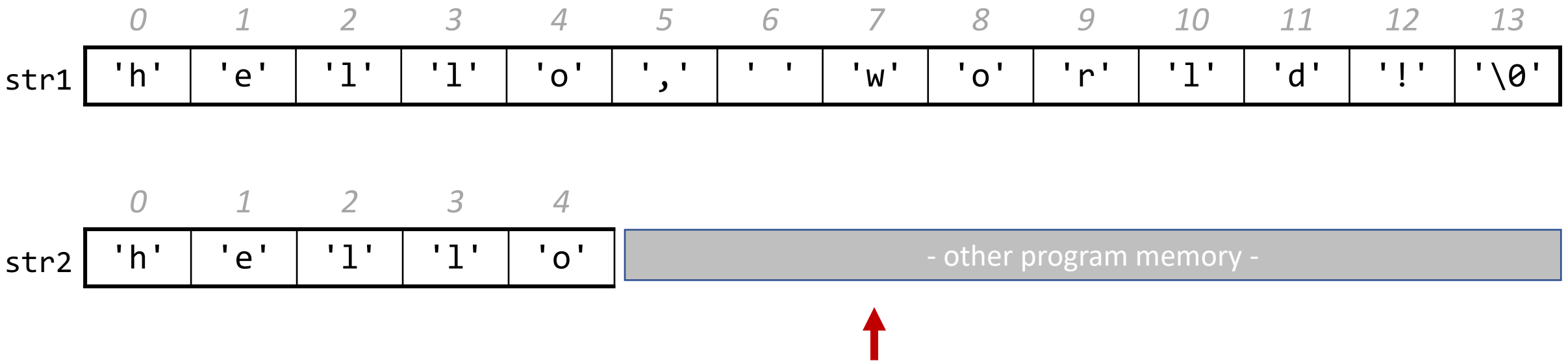
Copying Strings - strncpy

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



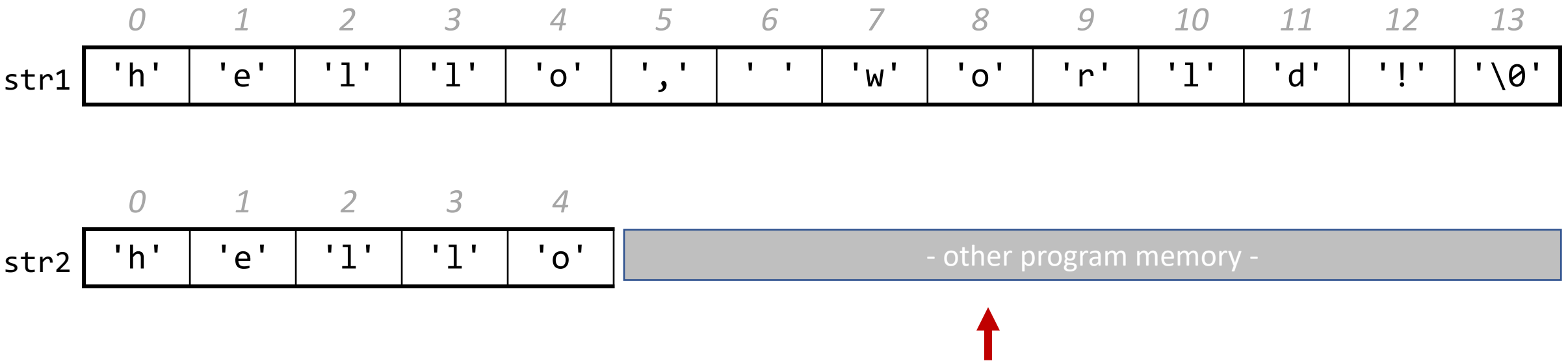
Copying Strings - strncpy

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



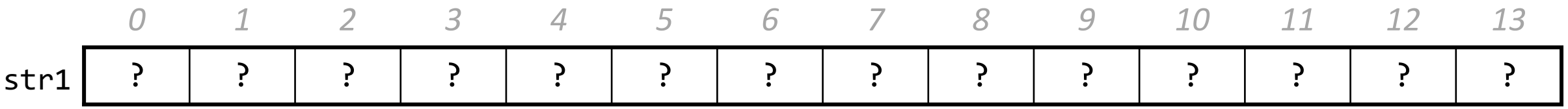
Copying Strings - strncpy

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



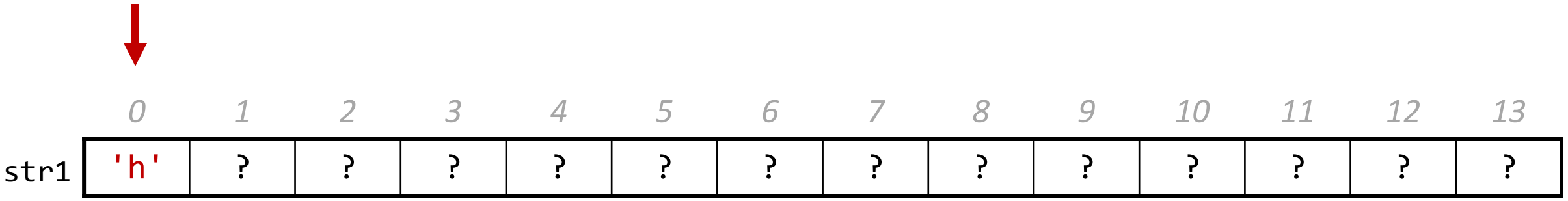
Copying Strings - strncpy

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



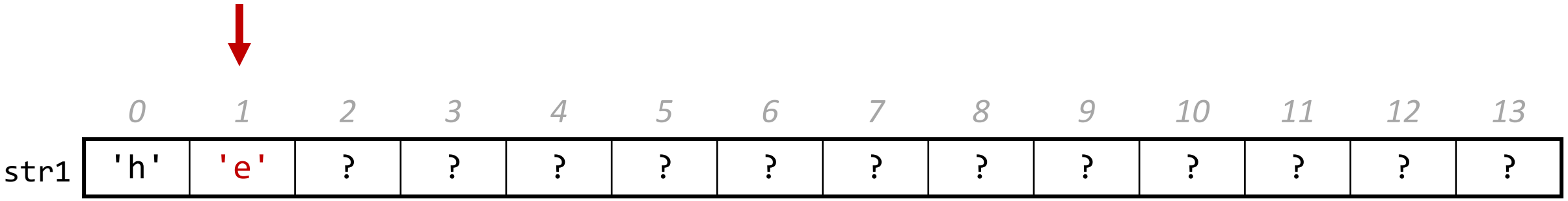
Copying Strings - strncpy

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



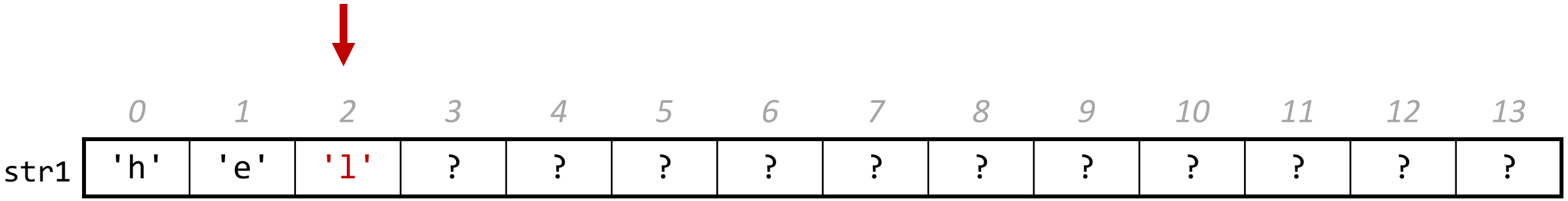
Copying Strings - strncpy

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



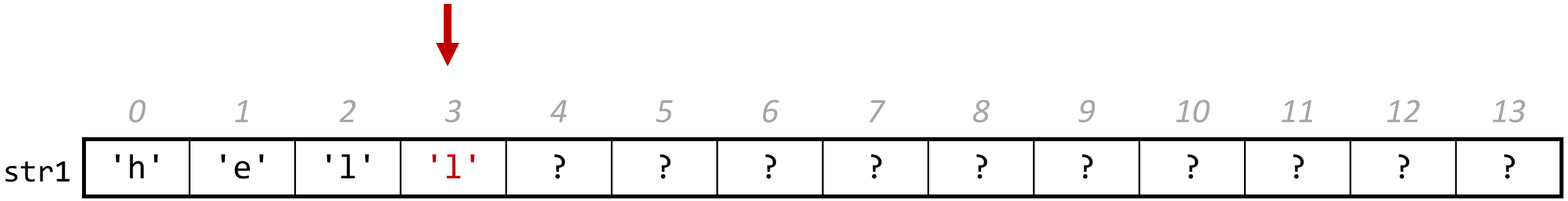
Copying Strings - strncpy

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



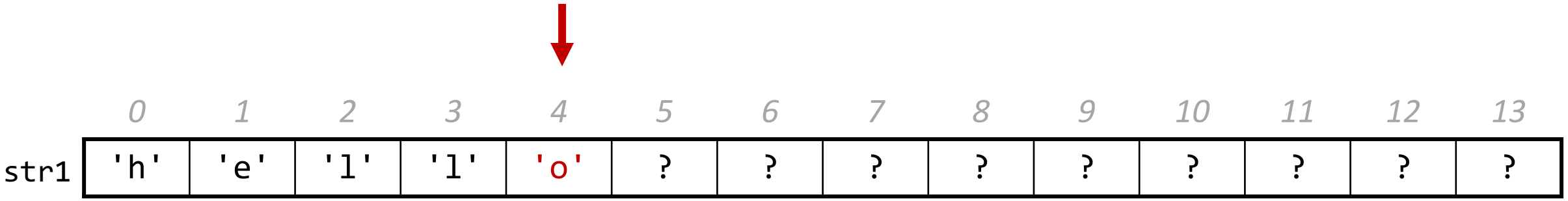
Copying Strings - strncpy

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



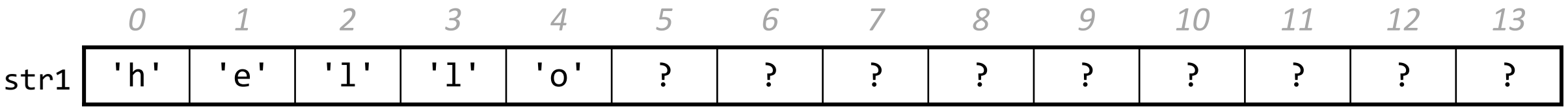
Copying Strings - strncpy

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



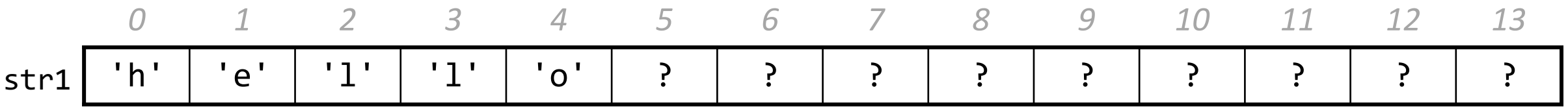
Copying Strings - strncpy

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



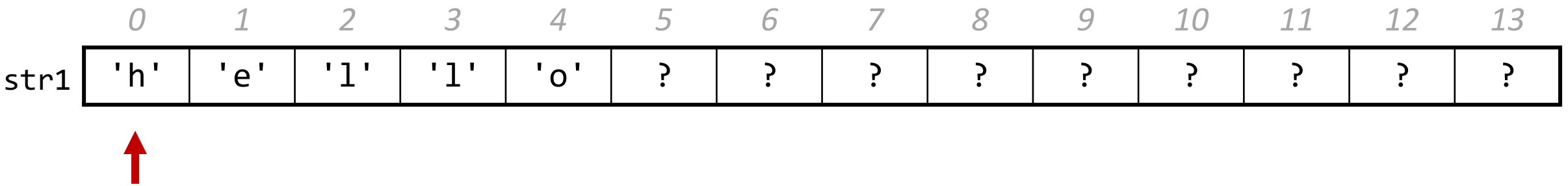
Copying Strings - strncpy

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



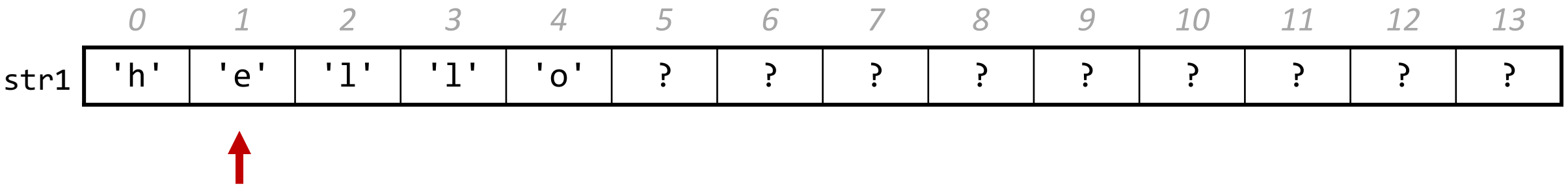
Copying Strings - strncpy

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



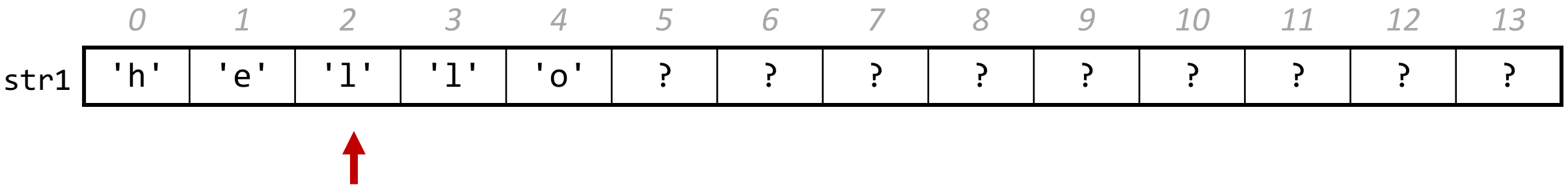
Copying Strings - strncpy

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



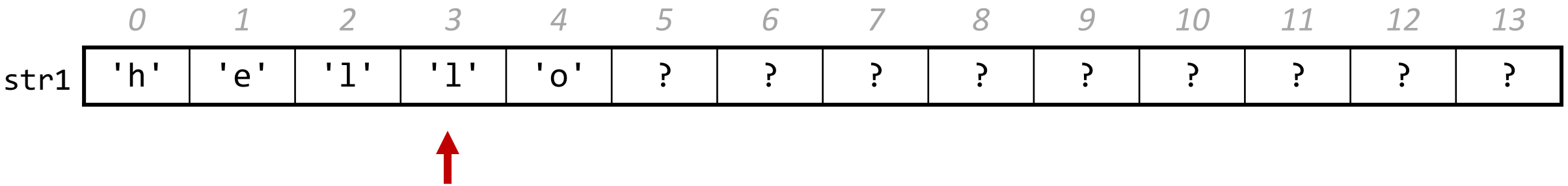
Copying Strings - strncpy

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



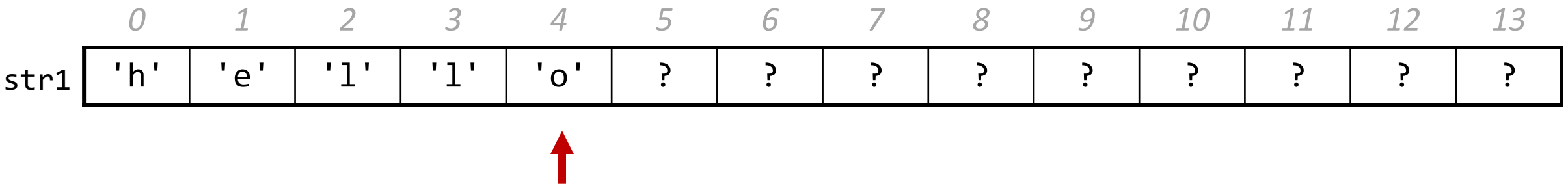
Copying Strings - strncpy

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



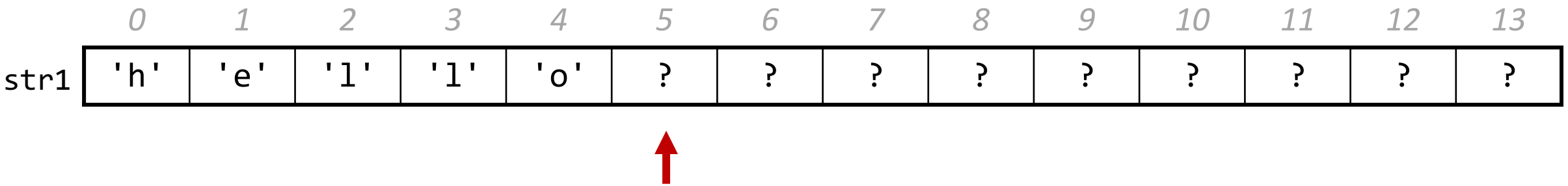
Copying Strings - strncpy

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



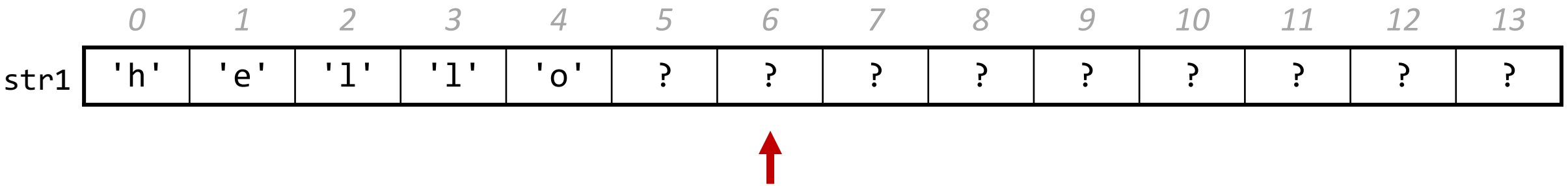
Copying Strings - strncpy

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



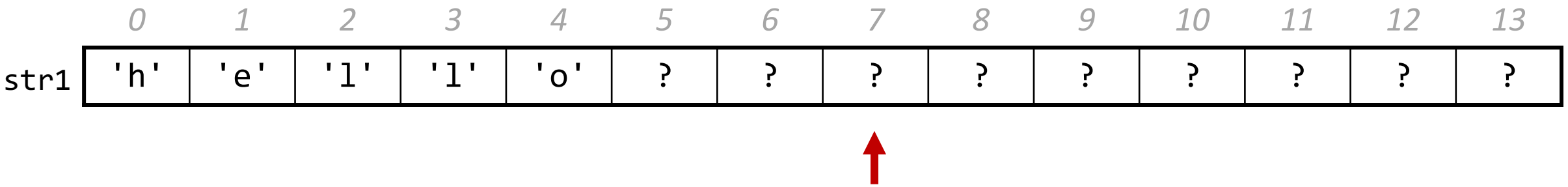
Copying Strings - strncpy

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



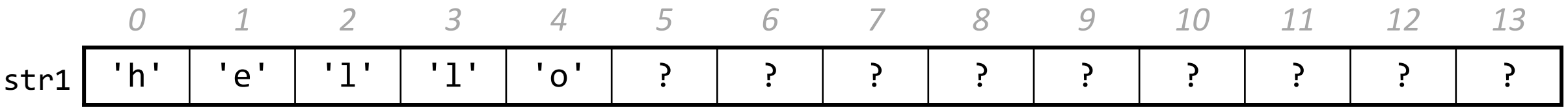
Copying Strings - strncpy

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



Copying Strings - strncpy

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




```
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

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

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**.

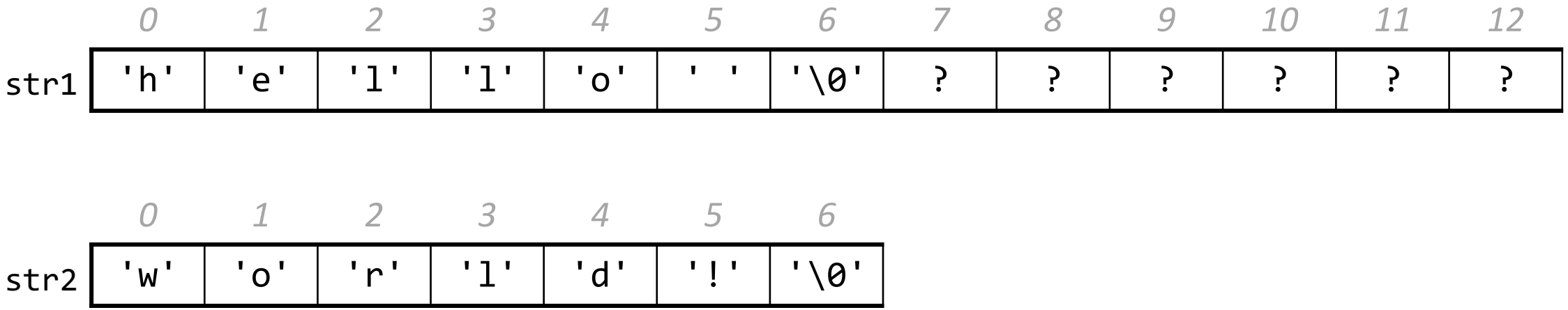
`strncat(dst, src, n)`: same, but concats at most n bytes from **src**.

```
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.

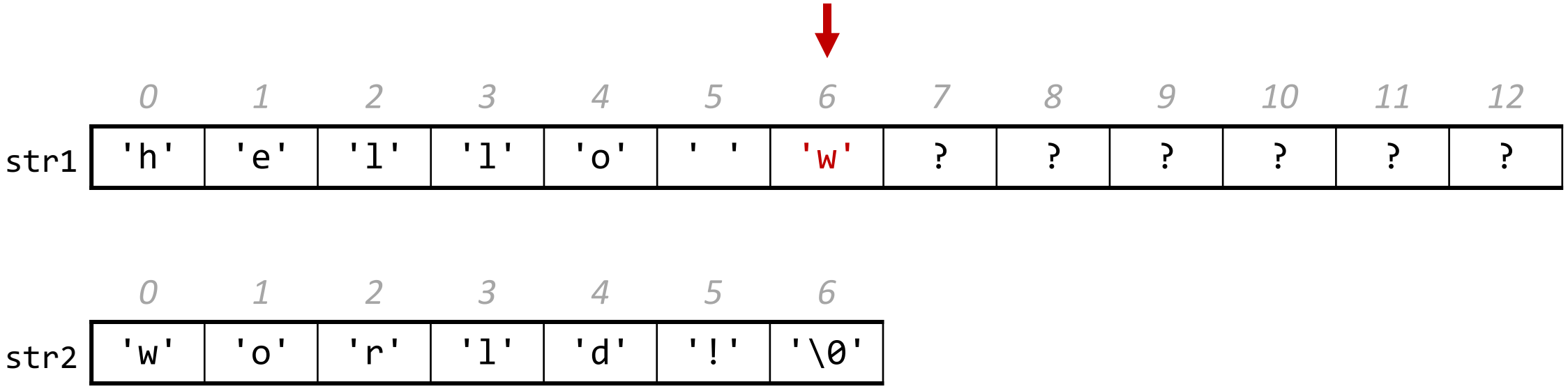
Concatenating Strings

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

strcat(str1, str2);
```



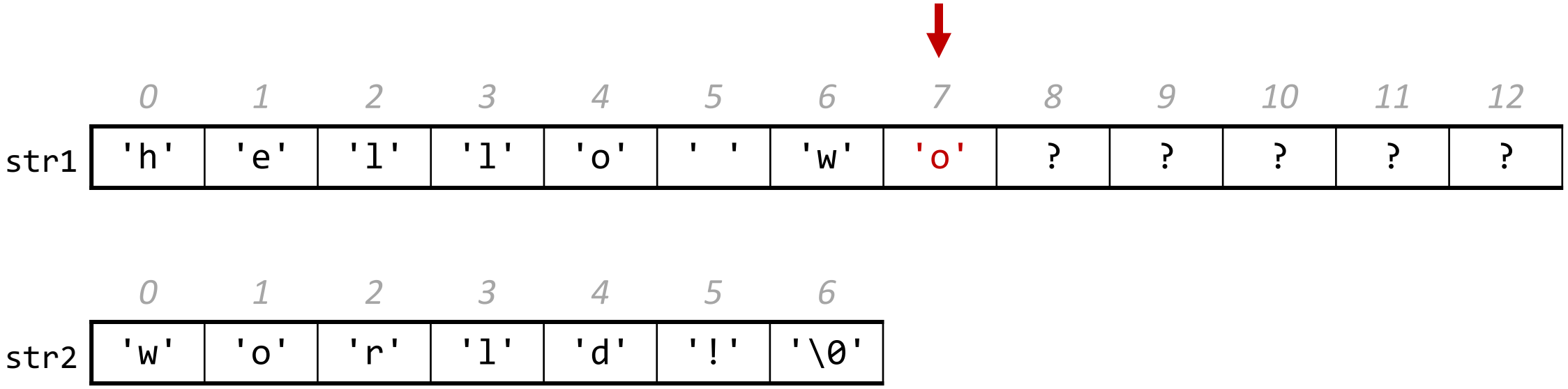
Concatenating Strings

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

strcat(str1, str2);
```



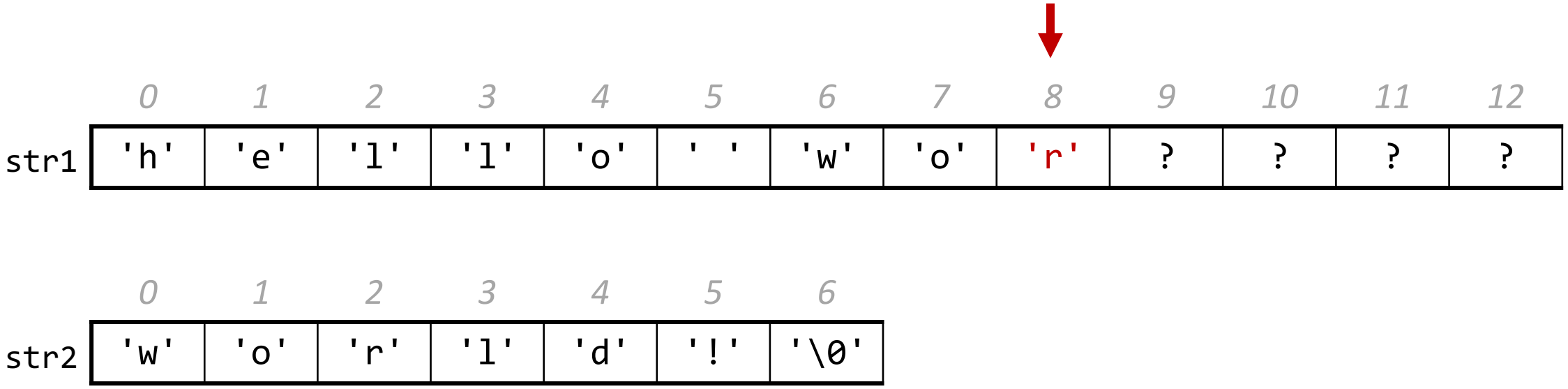
Concatenating Strings

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

strcat(str1, str2);
```



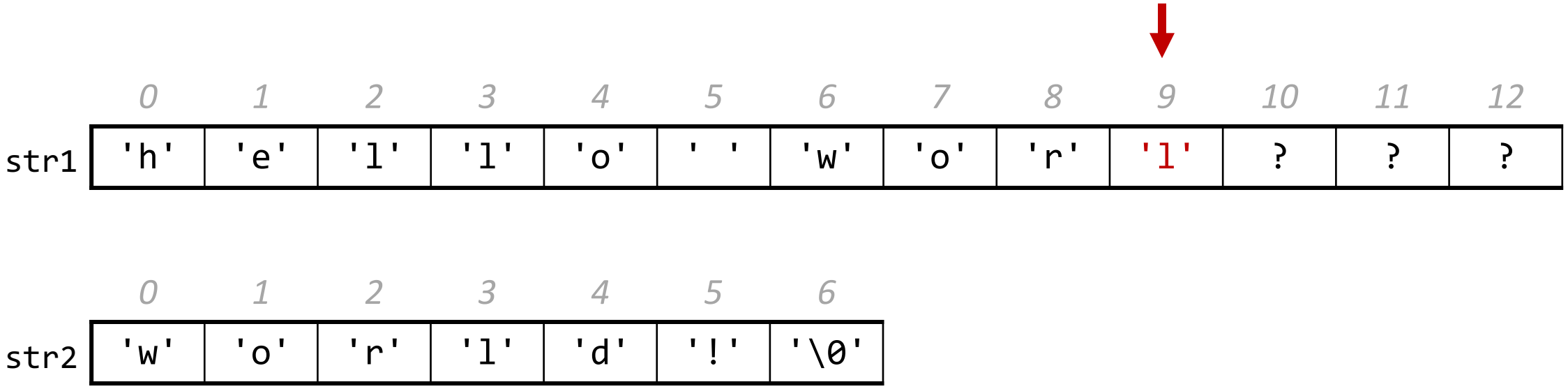
Concatenating Strings

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

strcat(str1, str2);
```



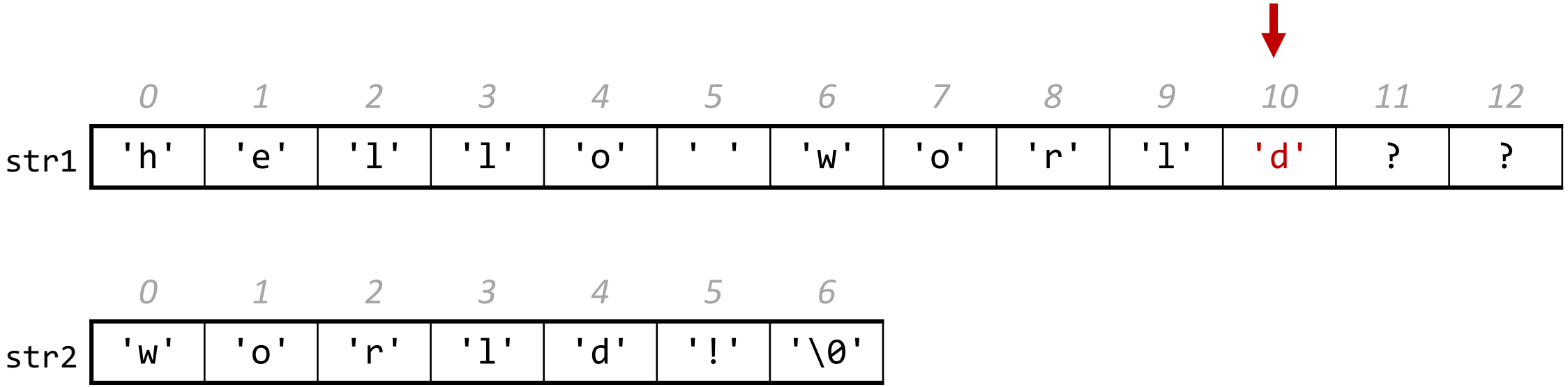
Concatenating Strings

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

strcat(str1, str2);
```



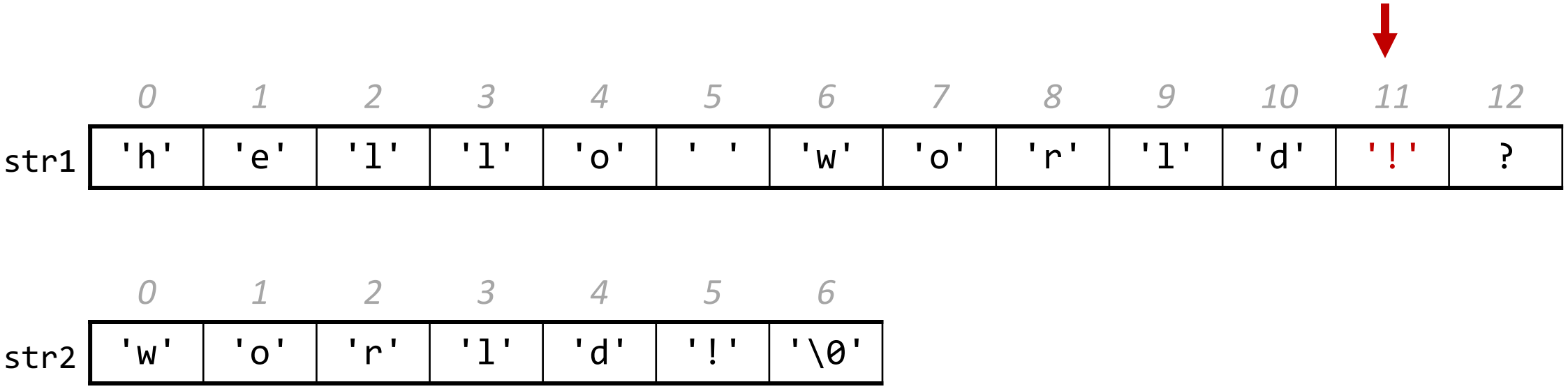
Concatenating Strings

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

strcat(str1, str2);
```



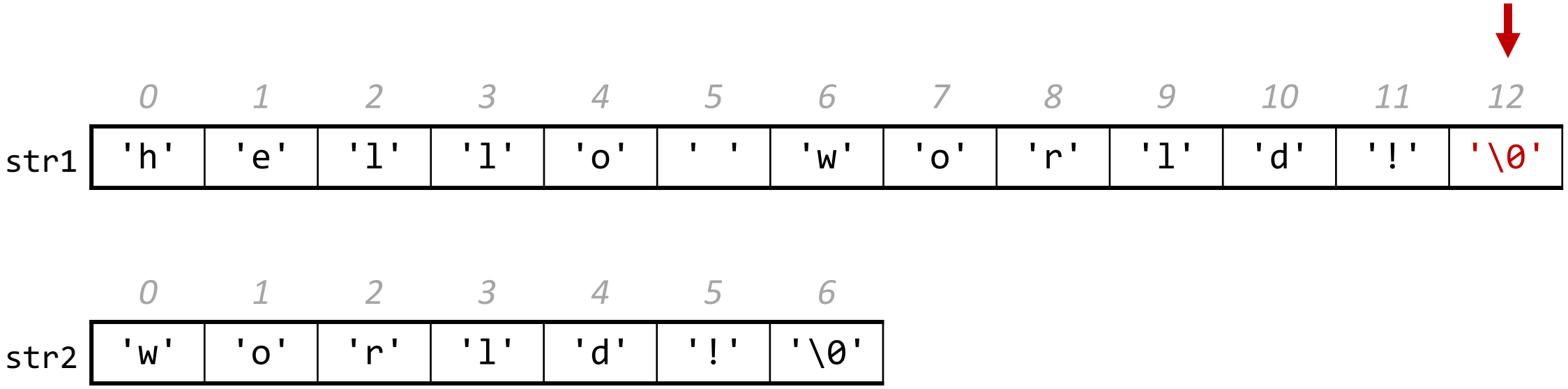
Concatenating Strings

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

strcat(str1, str2);
```



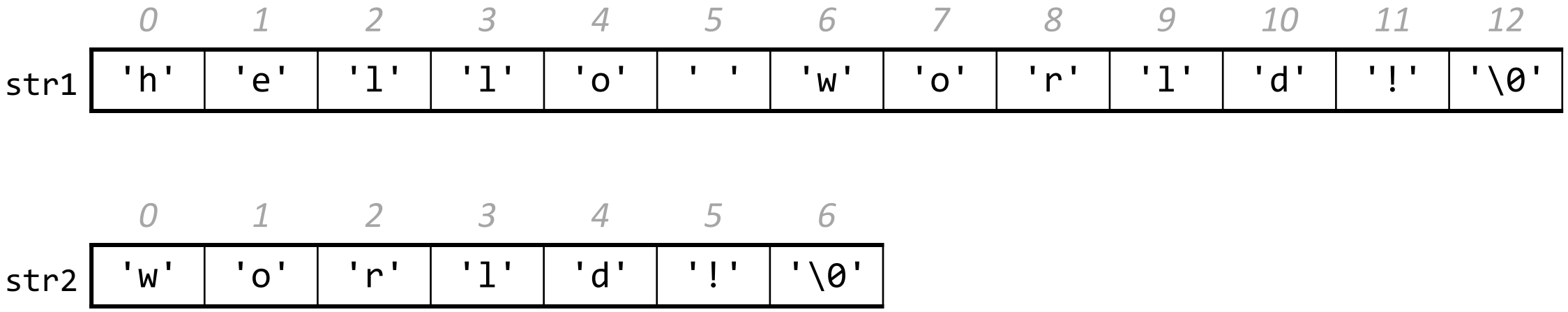
Concatenating Strings

```
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);
```



Substrings and char *

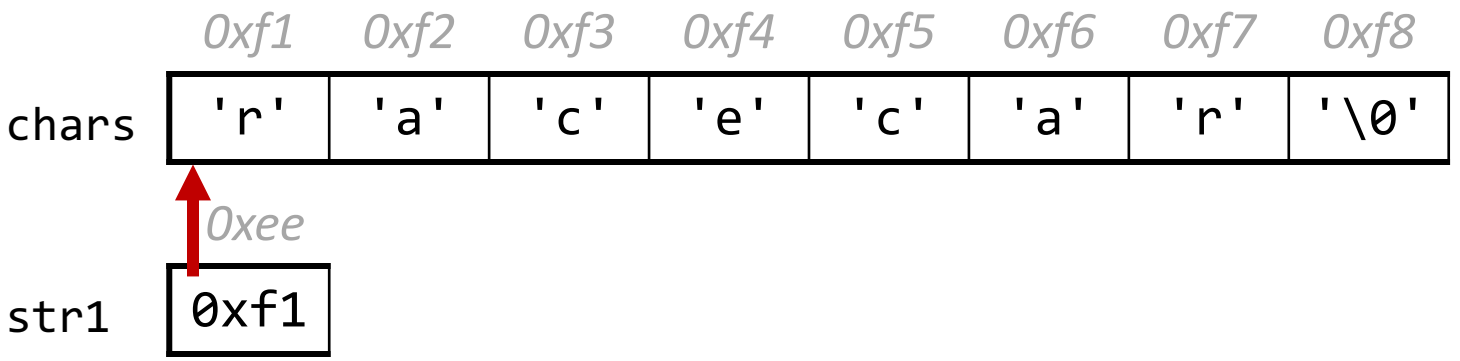
You can also create a char * variable yourself that points to an address within in an existing string.

```
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.

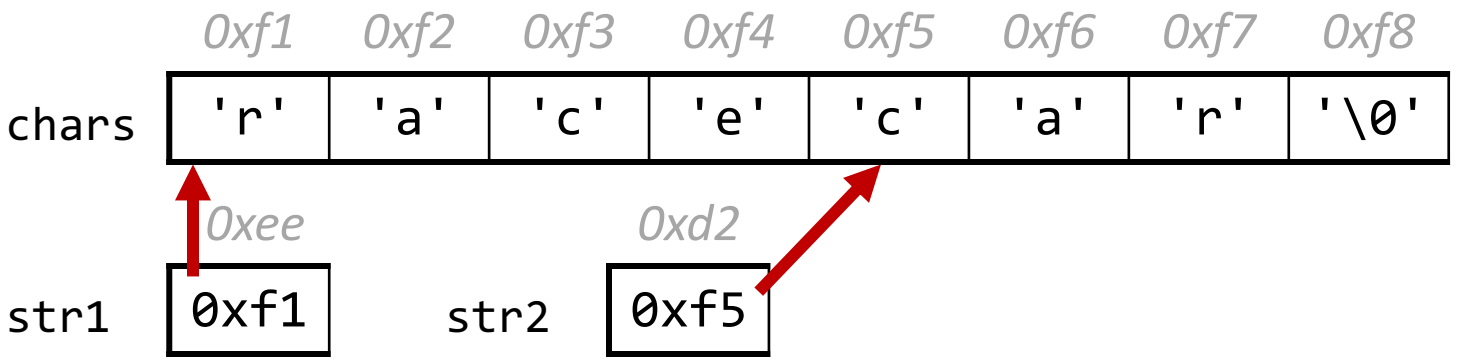
```
// Want just "car"
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
```



Substrings

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

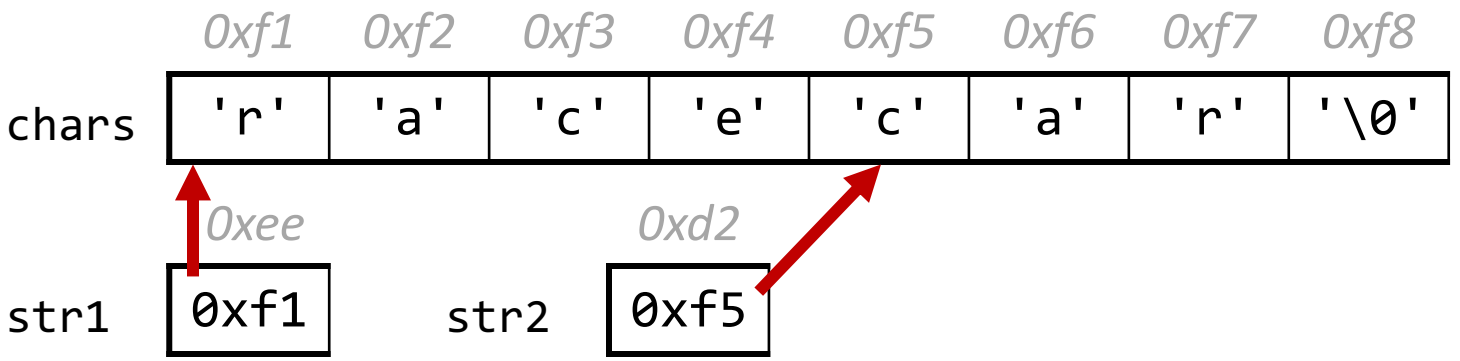
```
// Want just "car"
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
```



Substrings

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

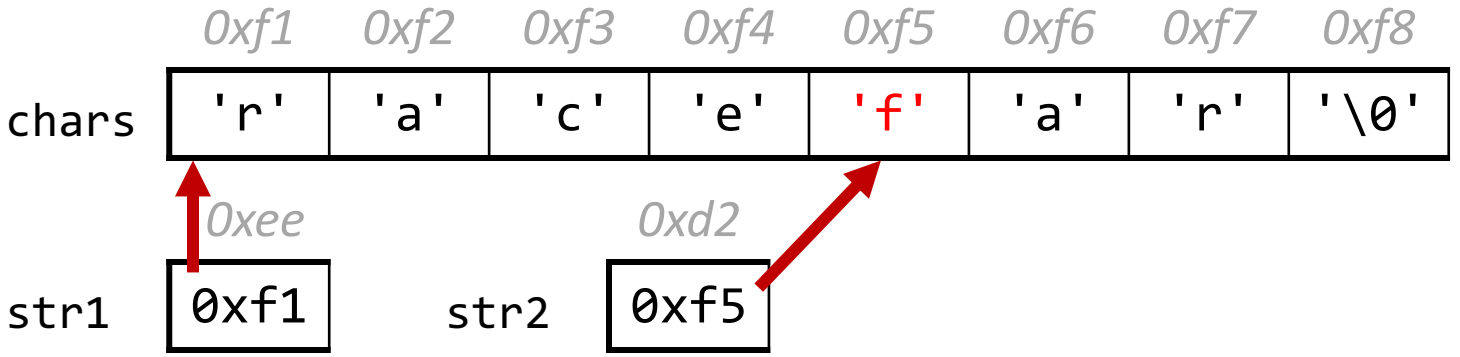
```
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
printf("%s\n", str1);          // racecar
printf("%s\n", str2);          // car
```



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!

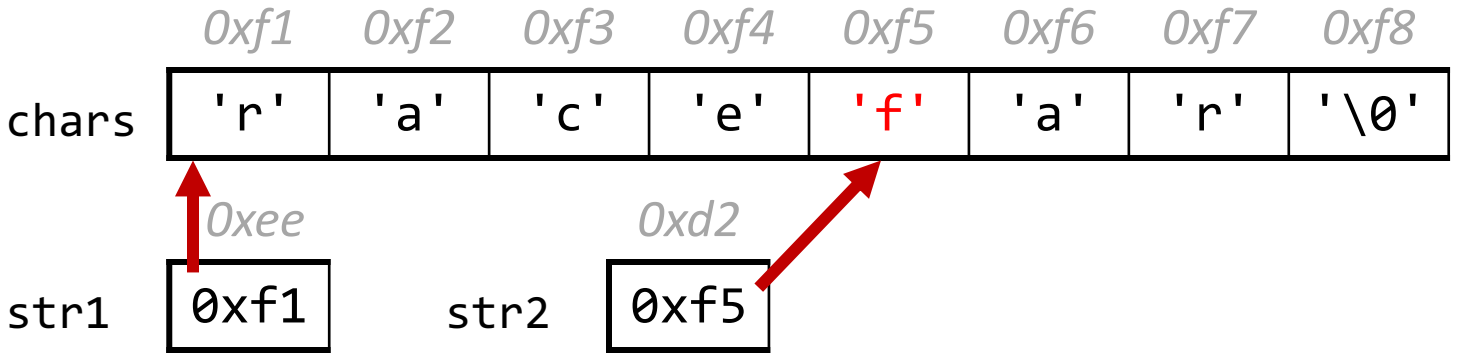
```
char chars[8];
strcpy(chars, "racecar");
char *str1 = chars;
char *str2 = chars + 4;
str2[0] = 'f';
printf("%s %s\n", chars, str1);
printf("%s\n", str2);
```



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";                    // not allowed!
---
char *myOtherString = myString;
myOtherString = somethingElse;                  // 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
```

Lecture Plan

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

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("DAISY")` should print:

```
D
DA
DAI
DAIS
DAISY
 AISY
  ISY
   SY
    Y
```

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("DAISY")` should print:

```
D
DA
DAI
DAIS
DAISY
 AISY
  ISY
   SY
    Y
```

Daisy!

Practice: Diamond

```
cp -r /afs/ir/class/cs107/lecture-code/lect4 .
```

Recap

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

Next time: more strings

Extra Practice

String copying exercise

```
1 char buf[ ____ ];
2 strcpy(buf, "Chadwick");
3 printf("%s\n", buf);
4 char *word = buf + 2;
5 strncpy(word, "ris", 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("Chadwick")`
F. Something else

Line 6: What is printed?

A. `risick`
B. `risdwick`
C. `Chris`
D. `Chrisick`
E. Something else
F. Compile error

String copying exercise

```
1 char buf[  9  ];
2 strcpy(buf, "Chadwick");
3 printf("%s\n", buf);
4 char *word = buf + 2;
5 strncpy(word, "ris", 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("Chadwick")`
F. Something else

Line 6: What is printed?

A. `risick`
B. `risdwick`
C. `Chris`
D. `Chrisick`
E. Something else
F. Compile error

Practice: String Copying/Concat-ing

- How could we replace a call to **strcat** with a call to **strcpy** instead?
- **Challenge**: implement our own **mystrcat** using other string functions.

```
// assume enough space in dst
strcat(dst, src);

// same as
strcat(dst + strlen(dst), src);
```