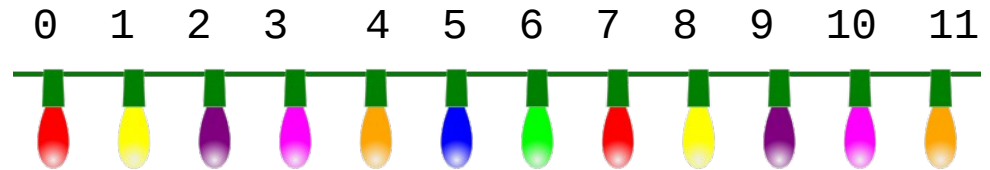


CS 261

Fall 2022

Mike Lam, Professor



[https://openclipart.org/detail/188824/
animated-christmas-lights-2](https://openclipart.org/detail/188824/animated-christmas-lights-2)

Arrays and Strings

Arrays and Pointers

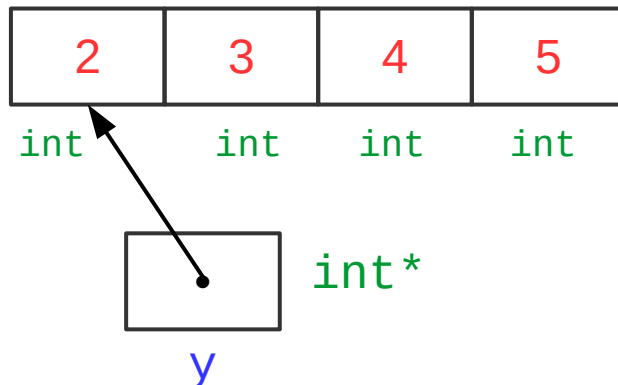
- In C, array names are just aliases that can be used as pointers

```
int y[] = {2, 3, 4, 5};    // these two are  
int *y  = {2, 3, 4, 5};    // roughly equivalent
```

- Indexing and dereferencing pointers are equivalent

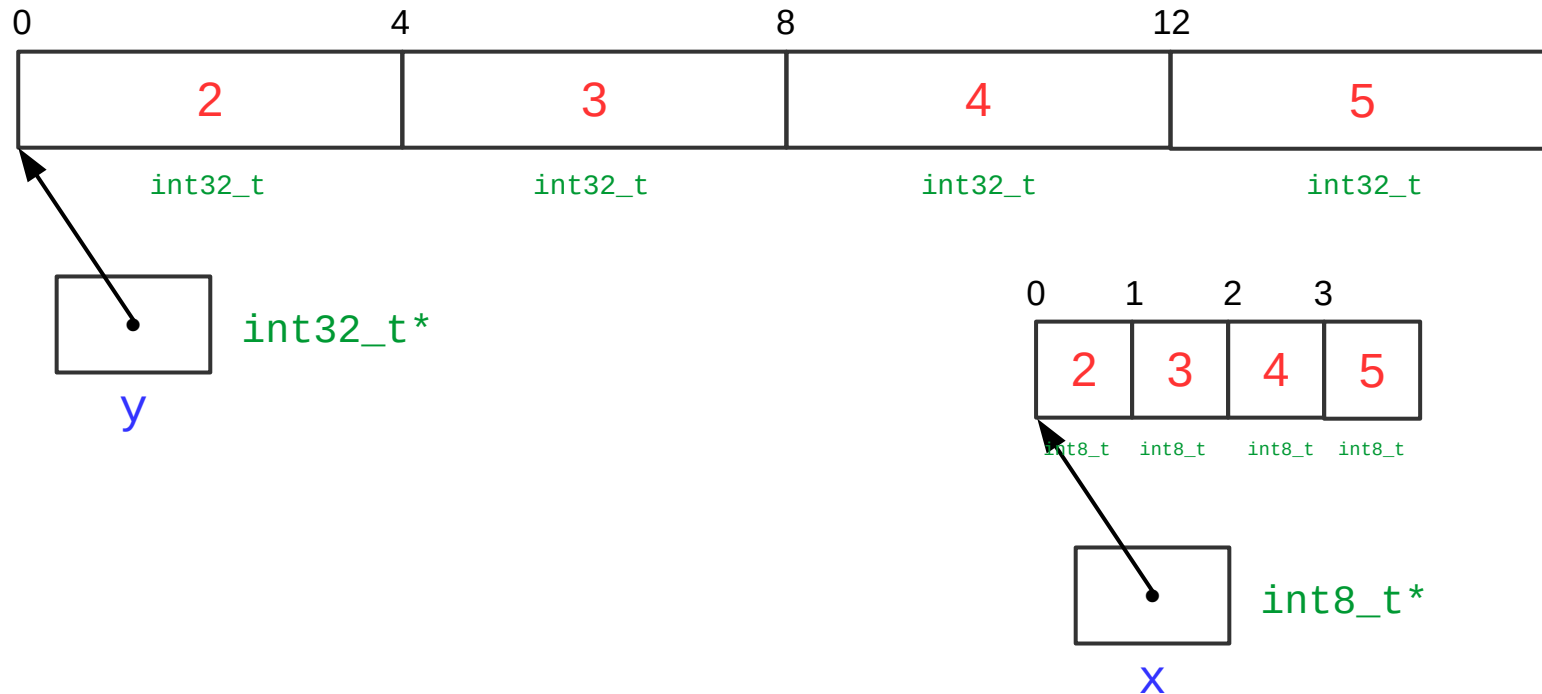
Side note: you can do arithmetic with pointers!

```
*y  ≡ y[0]           *(y+1) ≡ y[1]
```



Arrays and Pointers

- Pointer types are important!
 - If x is an `int8_t*`, $x[3]$ accesses element at byte offset $3 \times 1 = 3$
 - If y is an `int32_t*`, $y[3]$ accesses element at byte offset $3 \times 4 = 12$



Pointers

```
int x = 1;  
int y[4] = {2, 3, 4, 5};  
int *p = &x;  
*p = 6;  
p = y;  
*p = 7;
```

**What are the values of x and y
at the end?**

Pointers

```
int x = 1;
```

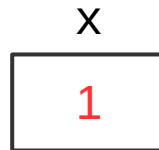
```
int y[4] = {2, 3, 4, 5};
```

```
int *p = &x;
```

```
*p = 6;
```

```
p = y;
```

```
*p = 7;
```



Pointers

```
int x = 1;
```

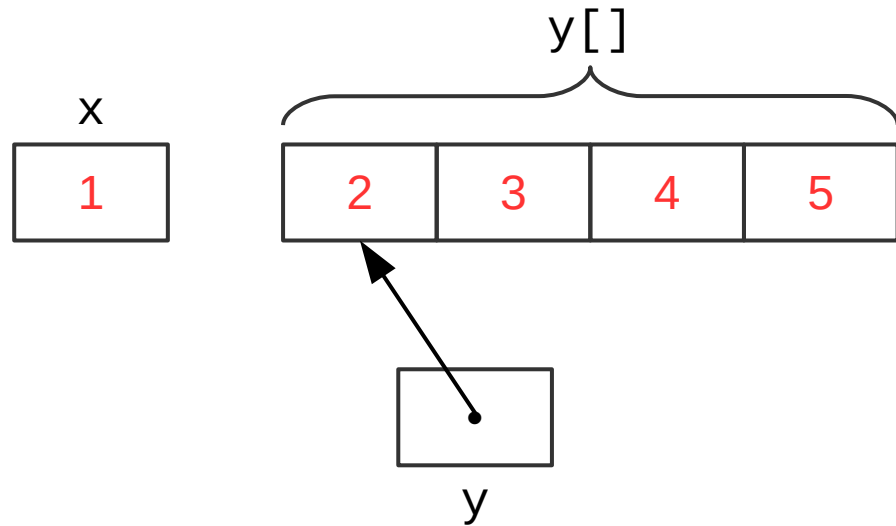
```
int y[4] = {2, 3, 4, 5};
```

```
int *p = &x;
```

```
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```

```
p = y;
```

```
*p = 7;
```



Pointers

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int x = 1;
```

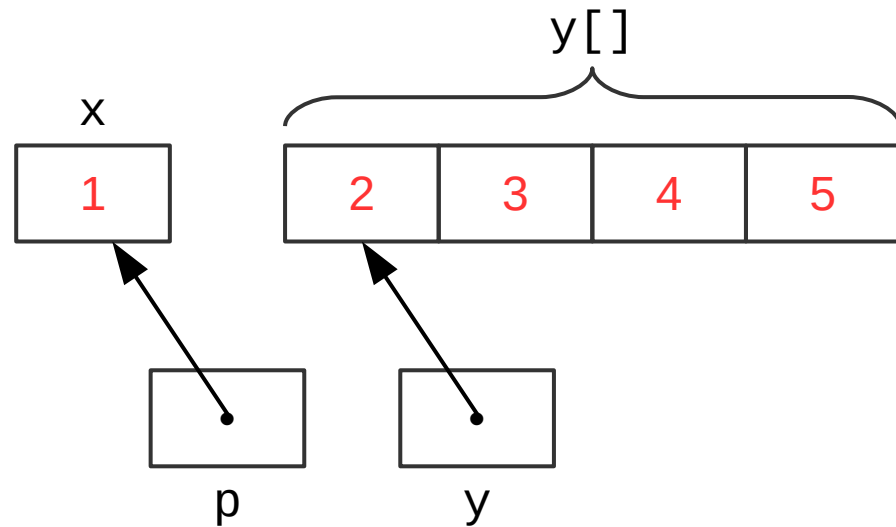
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int y[4] = {2, 3, 4, 5};
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int *p = &x;
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```

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Pointers

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int x = 1;
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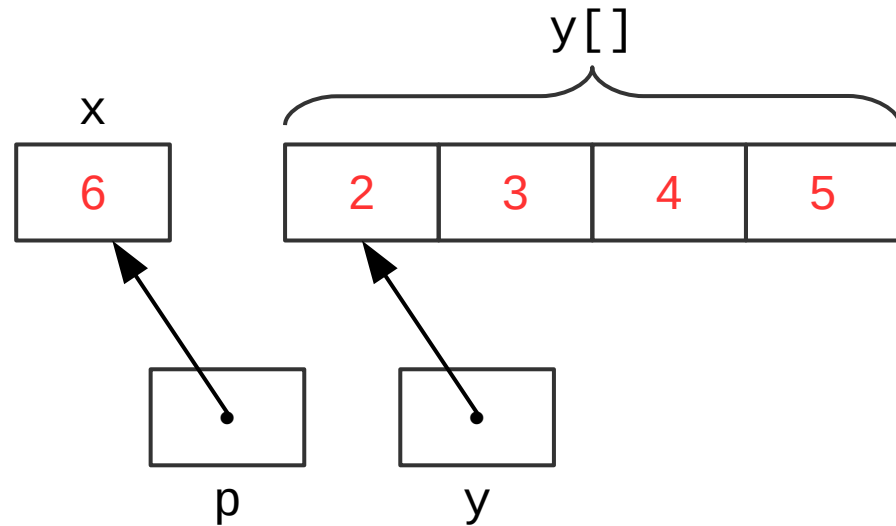
```
int y[4] = {2, 3, 4, 5};
```

```
int *p = &x;
```

```
*p = 6;
```

```
p = y;
```

```
*p = 7;
```



Pointers

```
int x = 1;
```

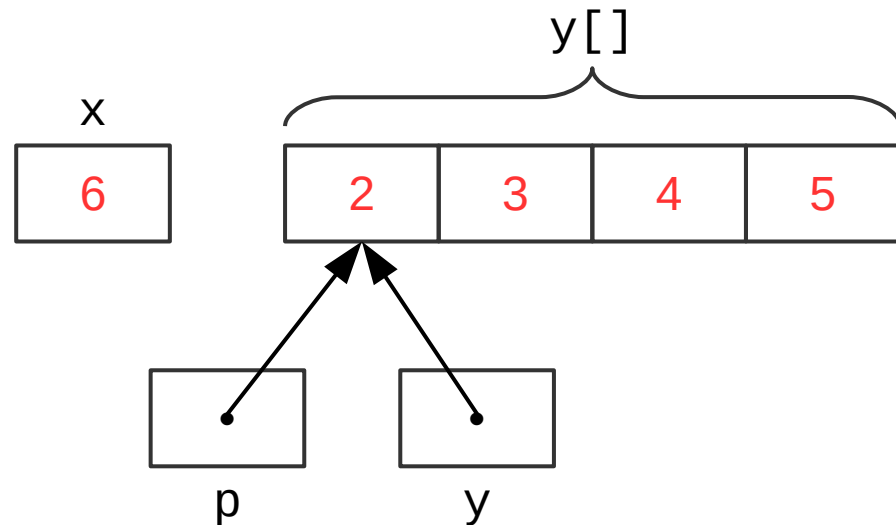
```
int y[4] = {2, 3, 4, 5};
```

```
int *p = &x;
```

```
*p = 6;
```

```
p = y;
```

```
*p = 7;
```



Pointers

```
int x = 1;
```

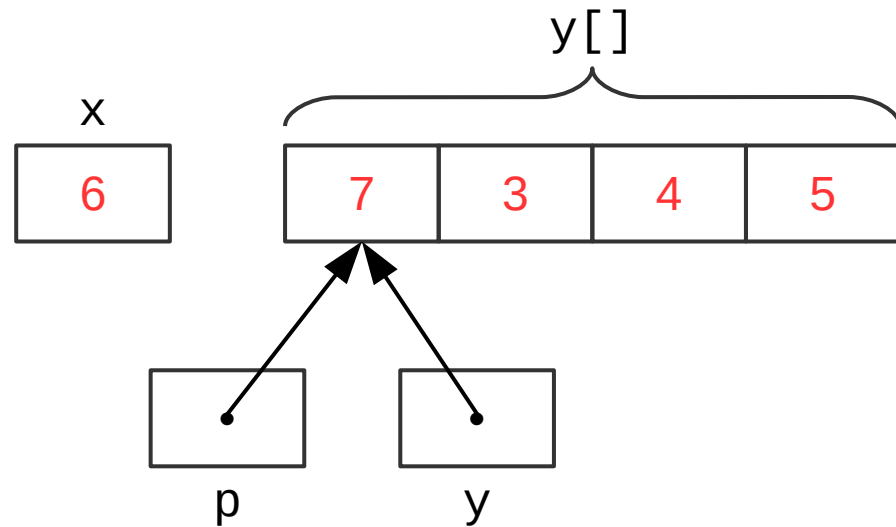
```
int y[4] = {2, 3, 4, 5};
```

```
int *p = &x;
```

```
*p = 6;
```

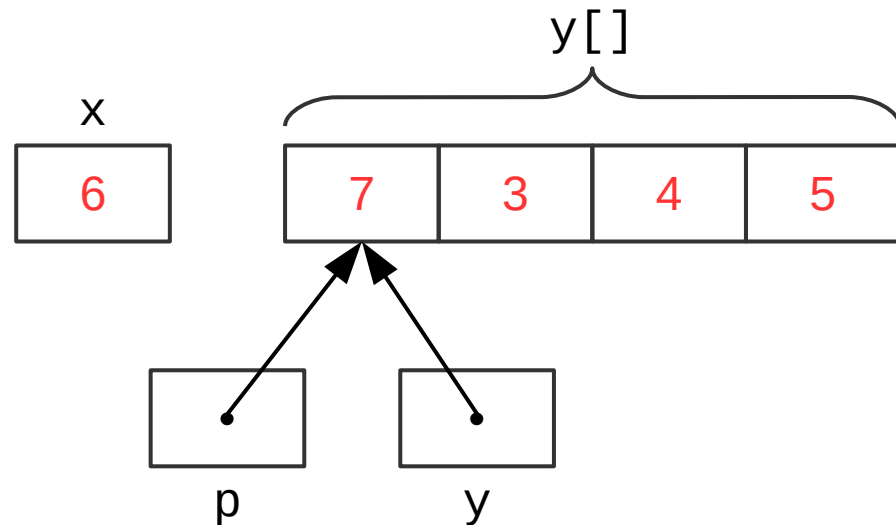
```
p = y;
```

```
*p = 7;
```



Pointers

```
int x = 1;  
int y[4] = {2, 3, 4, 5};  
int *p = &x;  
*p = 6;  
p = y;  
*p = 7;
```



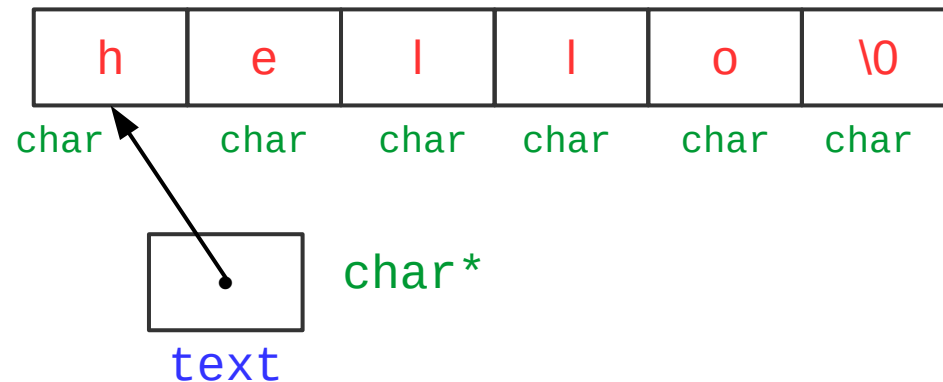
What about this?

```
p++;  
*p = 9;
```

Arrays and Pointers

- The same is (roughly) true for C "strings" (arrays of chars)

```
char text[] = "hello";    // read-write  
char *text  = "hello";    // read-only
```



C Strings

- C strings are a sequence of **ASCII** chars **terminated with null char** (`'\0'`)
 - Declare and initialize (static/stack, no explicit size needed):
 - `char *name = "John Smith";`
 - `char name[] = "John Smith";`
 - Declare only (static/stack, size needed):
 - `char name[11];`
 - Declare only (heap, size needed):
 - `char *name = (char*) malloc (sizeof(char) * 11);`
- Useful functions (need to `#include <string.h>`)
 - Find length: `strlen`
 - Copy string or convert / format data into string: `snprintf`
 - Convert to long / float: `strtol` / `strtof`
 - Compare strings: `strncmp`
 - Search for substring: `strstr`

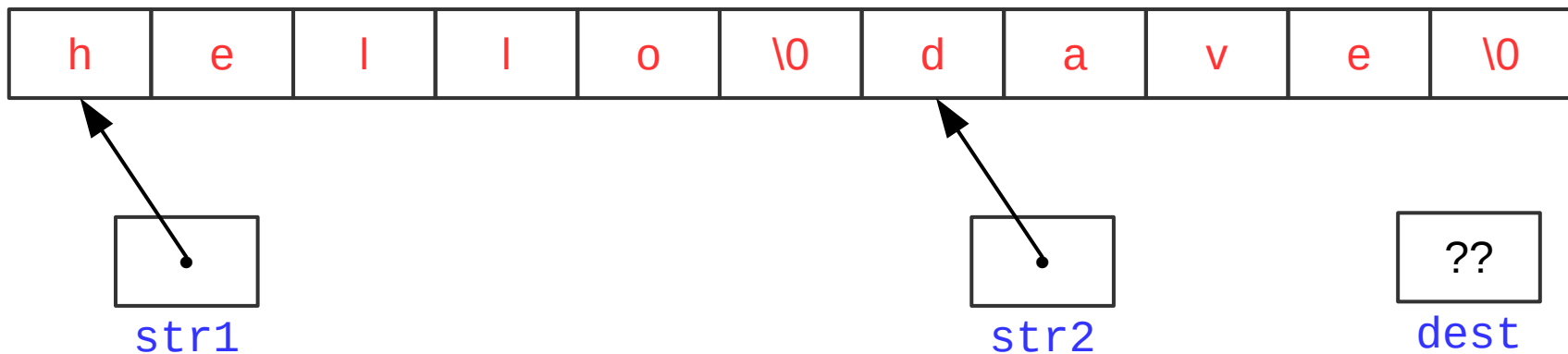
Information = Bits + Context

ASCII TABLE

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	0	[NULL]	32	20	[SPACE]	64	40	@	96	60	`
1	1	[START OF HEADING]	33	21	!	65	41	A	97	61	a
2	2	[START OF TEXT]	34	22	"	66	42	B	98	62	b
3	3	[END OF TEXT]	35	23	#	67	43	C	99	63	c
4	4	[END OF TRANSMISSION]	36	24	\$	68	44	D	100	64	d
5	5	[ENQUIRY]	37	25	%	69	45	E	101	65	e
6	6	[ACKNOWLEDGE]	38	26	&	70	46	F	102	66	f
7	7	[BELL]	39	27	'	71	47	G	103	67	g
8	8	[BACKSPACE]	40	28	(	72	48	H	104	68	h
9	9	[HORIZONTAL TAB]	41	29	)	73	49	I	105	69	i
10	A	[LINE FEED]	42	2A	*	74	4A	J	106	6A	j
11	B	[VERTICAL TAB]	43	2B	+	75	4B	K	107	6B	k
12	C	[FORM FEED]	44	2C	,	76	4C	L	108	6C	l
13	D	[CARRIAGE RETURN]	45	2D	.	77	4D	M	109	6D	m
14	E	[SHIFT OUT]	46	2E	.	78	4E	N	110	6E	n
15	F	[SHIFT IN]	47	2F	/	79	4F	O	111	6F	o
16	10	[DATA LINK ESCAPE]	48	30	0	80	50	P	112	70	p
17	11	[DEVICE CONTROL 1]	49	31	1	81	51	Q	113	71	q
18	12	[DEVICE CONTROL 2]	50	32	2	82	52	R	114	72	r
19	13	[DEVICE CONTROL 3]	51	33	3	83	53	S	115	73	s
20	14	[DEVICE CONTROL 4]	52	34	4	84	54	T	116	74	t
21	15	[NEGATIVE ACKNOWLEDGE]	53	35	5	85	55	U	117	75	u
22	16	[SYNCHRONOUS IDLE]	54	36	6	86	56	V	118	76	v
23	17	[ENG OF TRANS. BLOCK]	55	37	7	87	57	W	119	77	w
24	18	[CANCEL]	56	38	8	88	58	X	120	78	x
25	19	[END OF MEDIUM]	57	39	9	89	59	Y	121	79	y
26	1A	[SUBSTITUTE]	58	3A	:	90	5A	Z	122	7A	z
27	1B	[ESCAPE]	59	3B	;	91	5B	[	123	7B	{
28	1C	[FILE SEPARATOR]	60	3C	<	92	5C	\	124	7C	|
29	1D	[GROUP SEPARATOR]	61	3D	=	93	5D	]	125	7D	}
30	1E	[RECORD SEPARATOR]	62	3E	>	94	5E	^	126	7E	~
31	1F	[UNIT SEPARATOR]	63	3F	?	95	5F	_	127	7F	[DEL]

Copying strings

- In Java: `dest = str1 + str2; // copy strings`
 - What does this code do in C?



- Need to copy all characters from one string to another
 - First for `str1` and then for `str2`

Copying strings

- Old solution: `strcpy`

- Basically:

```
void strcpy (char *dest, char *src)
{
    for (int i = 0; src[i] != '\0'; i++) {
        dest[i] = src[i];
    }
}
```

- What happens if `src` isn't null-terminated?

OUT OF BOUNDS!!!

Copying strings

- Using `strcpy` is now considered **unsafe**
 - You are **not permitted** to use it in CS 261
- Solution: specify a maximum length that is safe to copy
 - This is usually the allocated length of the destination
- Older alternative: `strncpy`
 - Requires a maximum length
 - However, it does not guarantee the result is null-terminated
- Newer alternative: `strcpy_s`
 - However, it is not in the C99 standard
- **Better alternative: `snprintf`**
 - Safe, C99-standard, and more powerful than the other two

Output and string conversion

- `printf` and `snprintf` are conceptually similar
 - The former prints to standard out
 - The latter "prints" to a string (character array)
 - The latter can also copy strings and convert to strings
 - `snprintf(dest_str, max_size, "%s", src_str); // copy string`
 - `snprintf(dest_str, max_size, "%d", int_var); // int -> string`
 - `snprintf(dest_str, max_size, "%f", float_var); // float -> string`

```
int printf (                                char *format, ...)
```

```
int snprintf (char *buffer, int bufsize, char *format, ...)
```

↑
destination string;
must be at least
"bufsize" bytes

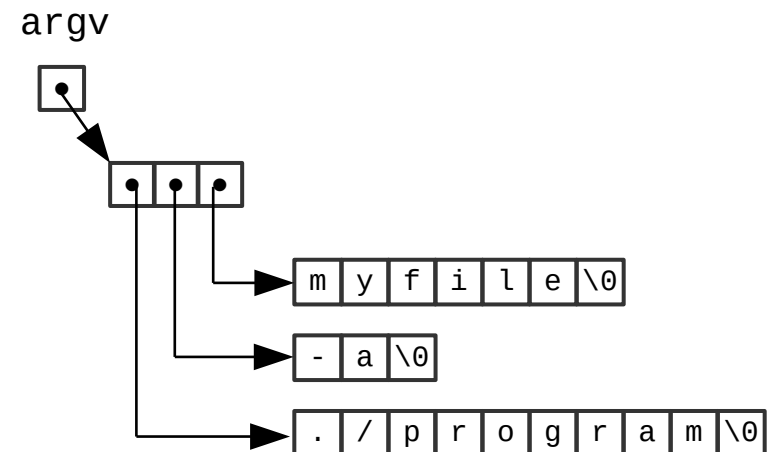
↑
maximum
size

Question

- How do we declare an array of strings?

Arrays of arrays

- Array of string (char*) pointers
 - Two (roughly) equivalent syntax choices
 - `char *name[];`
 - `char **name;`
 - Must allocate/initialize each sub-array separately
- Command-line parameters
 - `int main (int argc, char *argv[])`
 - Example: `./program -a myfile.txt`
 - `argc = 3`
 - `argv[0] = "./program"`
 - `argv[1] = "-a"`
 - `argv[2] = "myfile.txt"`



Modified "Hello, World"

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define STR_LEN 8

int main(int argc, char **argv)
{
    // check parameters
    if (argc != 3) {
        fprintf(stderr, "Usage: ./hello2 <fname> <lname>\n");
        exit(EXIT_FAILURE);
    }

    // convert name to "First L." format
    char fullname[STR_LEN];
    snprintf(fullname, STR_LEN, "%s %c.", argv[1], argv[2][0]);

    // output new full name
    printf("Hello, %s!\n", fullname);

    return EXIT_SUCCESS;
}
```