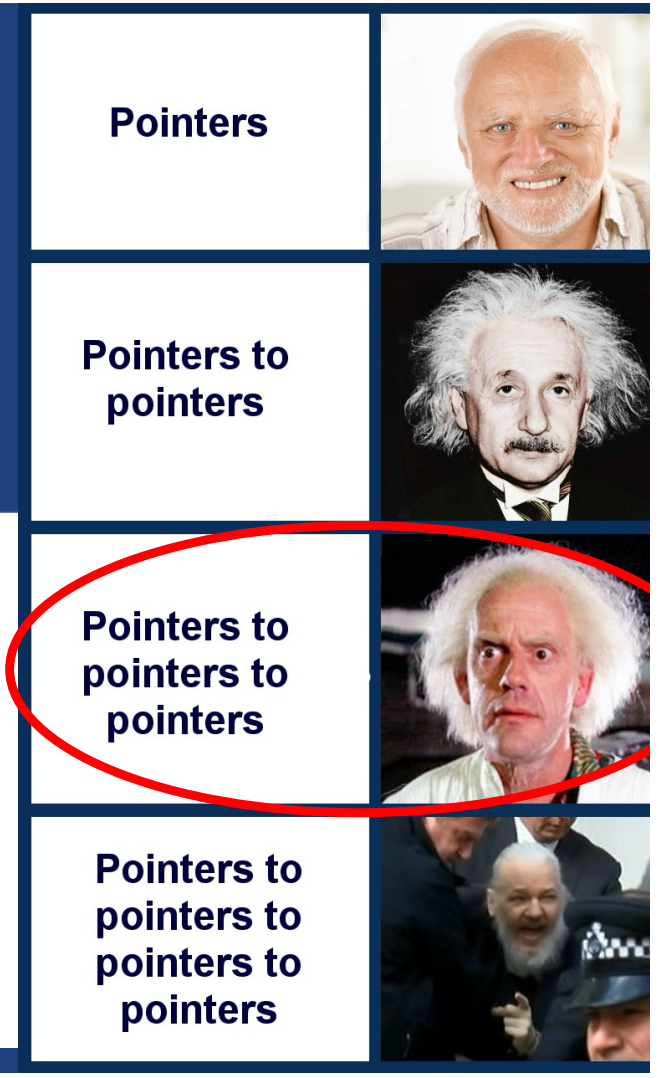
CMPSC 311 - Introduction to Systems Programming



More on Pointers and Arrays

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(Slides are mostly by *Professor Patrick McDaniel* and *Professor Abutalib Aghayev*)

Multidimensional Array Layout

PennState

- Arrays are laid out in row-major order
- int x[2][4] = {{1, 2, 3, 4}, {5, 6, 7, 8}};

1	2	3	4	5	6	7	8

- int x[3][2][4] = {{{1, 2, 3, 4}, {5, 6, 7, 8}},
  {{9, 10, 11, 12}, {13, 14, 15, 16}},
  {{17, 18, 19, 20}, {21, 22, 23, 24}}};

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

- Multidimensional arrays must have bounds for all dimensions except first
  - above, the followings are okay: int x[][4] = ...; int x[][2][4] = ...;
  - given an expression x[1][2], we need the length of the second row to compute offset

Arrays of Strings

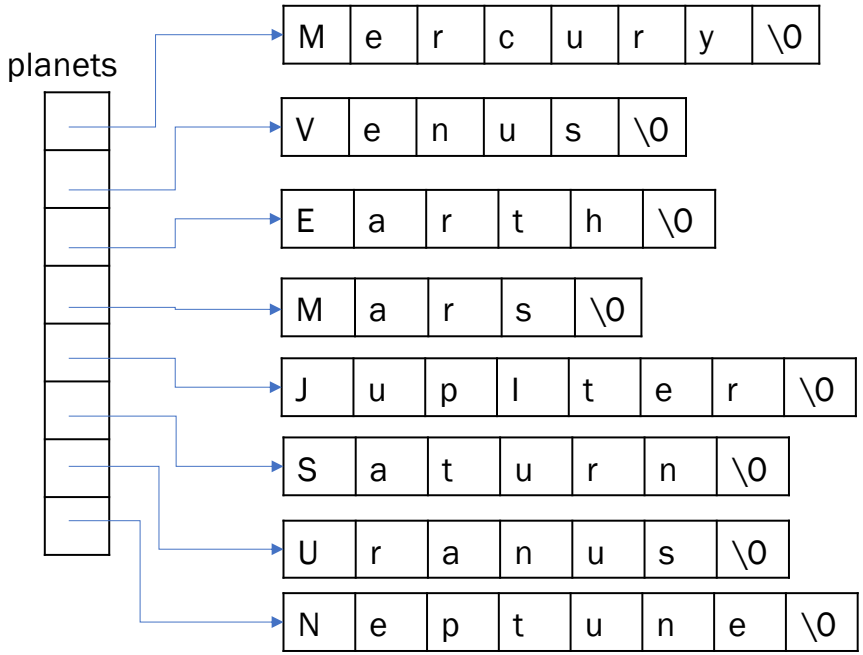
PennState

```
char planets[][8] = {
  “Mercury”,
  “Venus”,
  “Earth”,
  “Mars”,
  “Jupiter”,
  “Saturn”,
  “Uranus”,
  “Neptune”
};
```

M	e	r	c	u	r	y	\0
V	e	n	u	s	\0	\0	\0
E	a	r	t	h	\0	\0	\0
M	a	r	s	\0	\0	\0	\0
J	u	p	I	t	e	r	\0
S	a	t	u	r	n	\0	\0
U	r	a	n	u	s	\0	\0
N	e	p	t	u	n	e	\0

Arrays of Strings

```
char *planets[] = {
  “Mercury”,
  “Venus”,
  “Earth”,
  “Mars”,
  “Jupiter”,
  “Saturn”,
  “Uranus”,
  “Neptune”
};
```



Arrays of Strings

PennState

```
char *planets[] = {
  “Mercury”,
  “Venus”,
  “Earth”,
  “Mars”,
  “Jupiter”,
  “Saturn”,
  “Uranus”,
  “Neptune”
};
```

```
for (int i = 0; i < 8; ++i)
    if (planets[i][0] == ‘M’)
        printf(“%s\n”, planets[i]);
```

```
for (char **p = planets; p < planets + 8; ++p)
    if (**p == ‘M’)
        printf(“%s\n”, *p);
```

Command-line arguments

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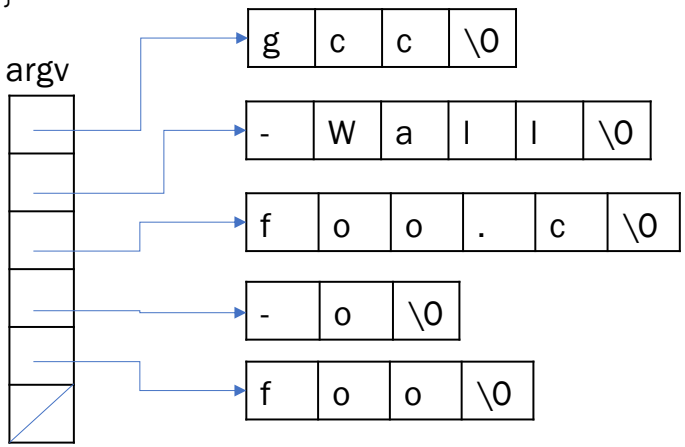
- So far, our main functions was accepting no (void) parameters:
  - `int main(void) { … }`
- We can access command-line arguments using following parameters:
  - `int main(int argc, char *argv[]) { … }`
- Since arrays decay into pointers, the following is OK too:
  - `int main(int argc, char **argv) { … }`

```
$ gcc –Wall foo.c –o foo
```

```
int main(int argc, char *argv[]) {
    for (int i = 0; i < argc; ++i)
        printf("%s\n", argv[i]);
    for (char **p = argv; *p != NULL; p++)
        printf("%s\n", *p);
}
```



Pointers to Pointers

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- We already know how to modify non-pointer variables through functions:
  - we pass their address to the function, i.e. we pass pointers to the variables

```
int x = 1, y = 2;
void swap(int *x, int *y) { int tmp = *x; *x = *y; *y = tmp; };
```

- What if we want to modify a pointer variable itself?

```
int x = 1, y = 2, *xp = &x, *yp = &y;
void swapception(int **xp, int **yp) { int *tmp = *xp; *xp = *yp; *yp = tmp; };
```

- Why? Data structures! (linked lists, trees, etc.)

Pointers to Pointers to Pointers

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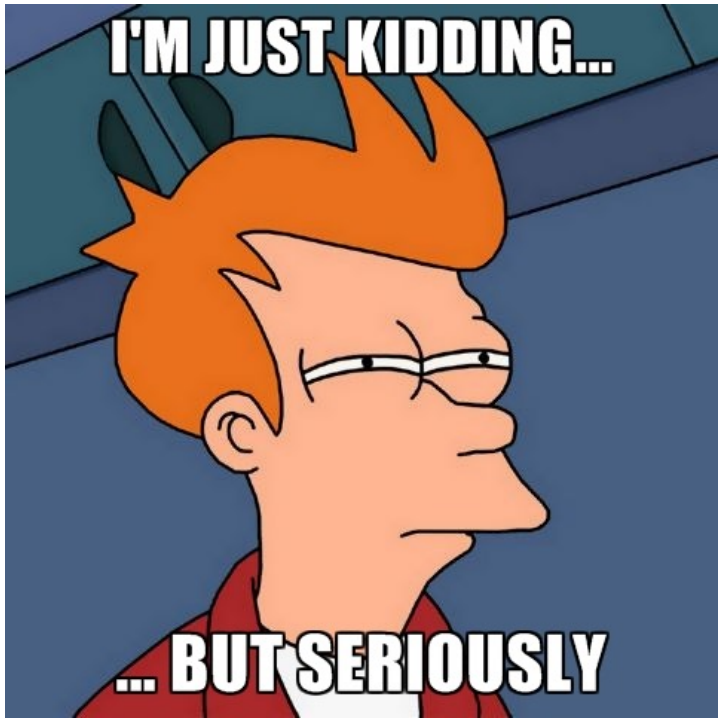
```
#include <stdio.h>

char *c[] = {
  "ENTER",
  "NEW",
  "POINT",
  "FIRST"
};

char **cp[] = {c+3, c+2, c+1, c};
char ***cpp = cp;

int main() {
  printf("%s", **++cpp);
  printf("%s ", *--*++cpp+3);
  printf("%s", *cpp[-2]+3);
  printf("%s\n", cpp[-1][-1]+1);
}
```



Pointers to Functions

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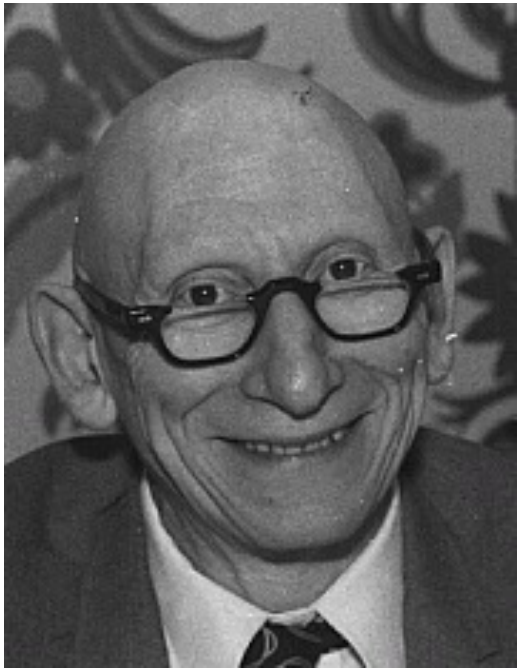
```
#include <stdio.h>
#include <stdlib.h>

// void qsort(void *base, size_t nmemb, size_t size, int (*compar)(const void *, const void *));

int values[] = { 88, 56, 100, 2, 25 };

int cmpfunc (const void * a, const void * b) {
   return *(int*)a - *(int*)b;
}

int main (void) {
   qsort(values, 5, sizeof(int), cmpfunc);
   return 0;
}
```

Prelude to Assignment 3

Edsger Dijkstra

Program testing can be used to show the presence of bugs, but never to show their absence.

Prelude to Assignment 3



Alan Perlis

Fools Ignore complexity. Pragmatists suffer it. Some can avoid it. Geniuses remove it.

Simplicity does not precede complexity, but follows it