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This is what we usually want from arrays: if we are thinking of `a` as indicating the start of an array we don't want its value wandering about in memory

And `b` is explicitly a variable pointer: if we need something variable, use a pointer

Arrays and Pointers

```
void foo(void)
{
  int a[4];
  a++;
}
```

gives an error message in the compiler

```
const.c: In function ’foo’:
const.c:5:3: error: lvalue required as increment operand
```

An “lvalue” is a thing that can appear on the left side of an assignment, e.g., an updatable variable

Arrays and Pointers

Clang says:

```
const.c:4:4: error: cannot increment value of type 'int [4]'
  a++;
  ~^
1 error generated.
```

Arrays and Pointers

```
void foo(void)
{
  int a[4], *b = a;
  b++;
}
```

is OK as `b` is allowed to vary

Arrays and Pointers

This may seem trivial but the following is very popular, particularly from Java-trained “programmers”

```
void foo(void)
{
  int a[4], *b;
  ...
  b = ...  // b gets some value
  ...
  a = b;
  ...
}
```

Bad!

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Clearly bad here, but Java allows lots of other types of composite objects (i.e., its “objects”) where this kind of thing is not so visually obviously bad

Strings and Pointers

Strings are just arrays of `char`; string variables thus have type pointer to `char`, i.e., `char *`

We can have

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char a[4] = "xyz", *b;
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just as before; `a` can be used as a `char *`

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We can have

```
char a[4] = "xyz", *b;
```

just as before; `a` can be used as a `char *`

Now the value of `a` is a (constant) pointer to an array of 4 characters; the value of `b` is nothing in particular

Strings and Pointers

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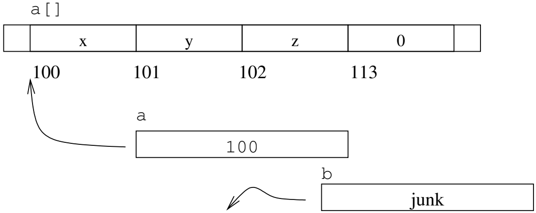
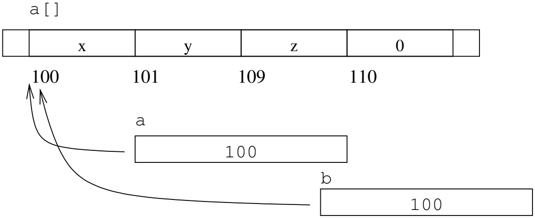
Just the value in `a` (an address) is copied into `b`, nothing more

Strings and Pointers



Strings and Pointers



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The point is that `a` and `b` are simply pointers to where the characters live: they are not the characters

The characters are `a[0]`, `a[1]`, etc.

To copy the characters we can go
`b[0] = a[0]; b[1] = a[1]; ...`
more likely using a `for` loop

Strings and Pointers

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strcpy(b, a);
```

will copy the contents of the (zero-terminated) string pointed to by `a` to the area of memory pointed to by `b`

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will copy the contents of the (zero-terminated) string pointed to by `a` to the area of memory pointed to by `b`

Note `strcpy` will continue copy characters until it hits a 0 in `a`

Strings and Pointers

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Forgetting these is a popular source of bugs

Strings and Pointers

```
char a[] = "hello world", b[4];
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```

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Exercise. What is the output from the following?

```
char a[] = "the cat sat on the mat", *b;
b = a;
b[4] = 'r';
printf("a is '%s'\nb is '%s'\n", a, b);
```

Exercise. What is the bug here?

```
char a[] = "the cat sat on the mat", *b;
strcpy(b, a);
```

Strings and Pointers

Exercise. What about

```
char a[] = "hello", b[5];
strcpy(b, a);
```

Strings and Pointers

Exercise. What about

```
char a[] = "hello", b[5];
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Look up the function `strlen`. Reimplement it yourself

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When we run a program we often want to pass some values to that program: `./summit 23 42`

The arguments passed to the program are presented to the `main` function

Strings and Pointers

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

int main(int argc, char *argv[])
{
  int n, m;

  if (argc < 3) {
    printf("Not enough arguments!\n");
    return 1;
  }

  n = atoi(argv[1]);
  m = atoi(argv[2]);
  printf("sum is %d\n", n + m);

  return 0;
}
```

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- `argv` has type array of pointer to `char`; namely an array of strings: read this as `char (*argv)[]`, i.e., an array of `char *`
- The length of this array is `argc`, of course
- Some people declare `argv` as `char **argv` and play tricks with changing the (now non-constant) variable `argv`

Strings and Pointers

Exercise. Compare the declarations

```
int One(char *one[]) ...
int Two(char *(two[])) ...
int Three(char **three) ...
```

Strings and Pointers

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- The arguments to `main` are passed in as strings; we will have to convert a string `"23"` to an integer 23
- `if (argc < 3) ...` remember the program name is included in the count
- The function `atoi` converts a string containing an integer to an integer. See `man atoi`

Strings and Pointers

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You will have to just explore!

Arrays and Pointers

Exercise. Look up `strncpy` (extra ’n’ in there)

Exercise. What about `3[a]`? Or `0[a+3]`? Or `(a+3)[0]`?

Exercise. For `int a[4], *b;` compare `sizeof(a)`, `sizeof(*a)`, `sizeof(b)`, `sizeof(*b)`

Exercise. Read the specification for `atoi` and implement it for yourself (give your version a different name!)

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One more thing about pointers: the `void` pointer

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void *memcpy(void *dest, const void *src, size_t
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This allows us to write functions that act on arbitrary pointers: `memcpy` copies arbitrary blocks of objects, be it `int`s, `double`s, or `struct` whatevers

Pointers

```
int a[10], b[10];
double x[5], y[5];
...
memcpy(b, a, 10*sizeof(int));
memcpy(y, x, 5*sizeof(double));
```

copies 10 integers-worth of bytes from where `a` points to where `b` points; and 5 doubles-worth of bytes from `x` points to where `y` points

Pointers

Exercise. What is the error here?

```
int a[5];
void *b;
...
b = a;
b[0] = b[1] + b[2];
```

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The syntax is
`(typename)expression`
to convert the value of the expression to have type `typename`

Casting

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As mentioned previously, it is merely the interpretation of the bits at those addresses that may differ

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int *a = (int*)42;
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Exercise. Compare `n + 1` and `p + 1`

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Find out what happens with
`int n = (int)1e100;`

Casting

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the value of `b` is identical to the value of `a`

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the value of `b` is identical to the value of `a`

It is entirely a message to the compiler to interpret the bits at that address differently

Casting

`a` says look at this address and regard the 8 bytes there as a double

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Exercise. Read up on automatic pointer coercions, including `void*`

Structures and Pointers

Arrays are fixed-size structures in C

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Lists and other dynamic datastructures are made easy in C by the use of structures and pointers

Structures and Pointers

We can define

```
struct intlist {
  int val;
  struct intlist *next;
};
```

This structure contains an integer value and a pointer to the next item in the list

Structures and Pointers

Exercise. Reflect for a moment why

```
struct intlist {
  int val;
  struct intlist next;
};
```

does not make sense

Structures and Pointers

We can define a few values

```
struct intlist a, b, c;
a.val = 12; a.next = &b;
b.val = 34; b.next = &c;
c.val = 56; c.next = 0;
```

N.B. this is *not* the right way to do this kind of thing

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So `a` is the head of the list; `b` is next; then `c`

We conventionally terminate the list with a 0 pointer as this turns out to be useful later (think about Boolean values)

Structures and Pointers

In fact, C defines a symbol `NULL` that is the same as zero, but visually indicates a null pointer, i.e., end of list:

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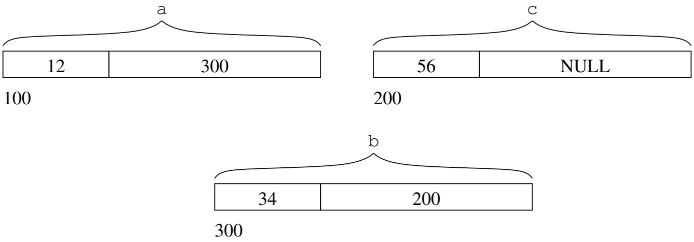
In fact, NULL is shorthand for `(void*)0`

Structures and Pointers

In memory, each instance of the structure contains the value and a pointer



Each instance can be anywhere in memory the system wants to put them; they are not necessarily in the order they appear in the code or the order they are created

Structures and Pointers

Note for geeks: there may well be alignment padding between the `int` and the pointer