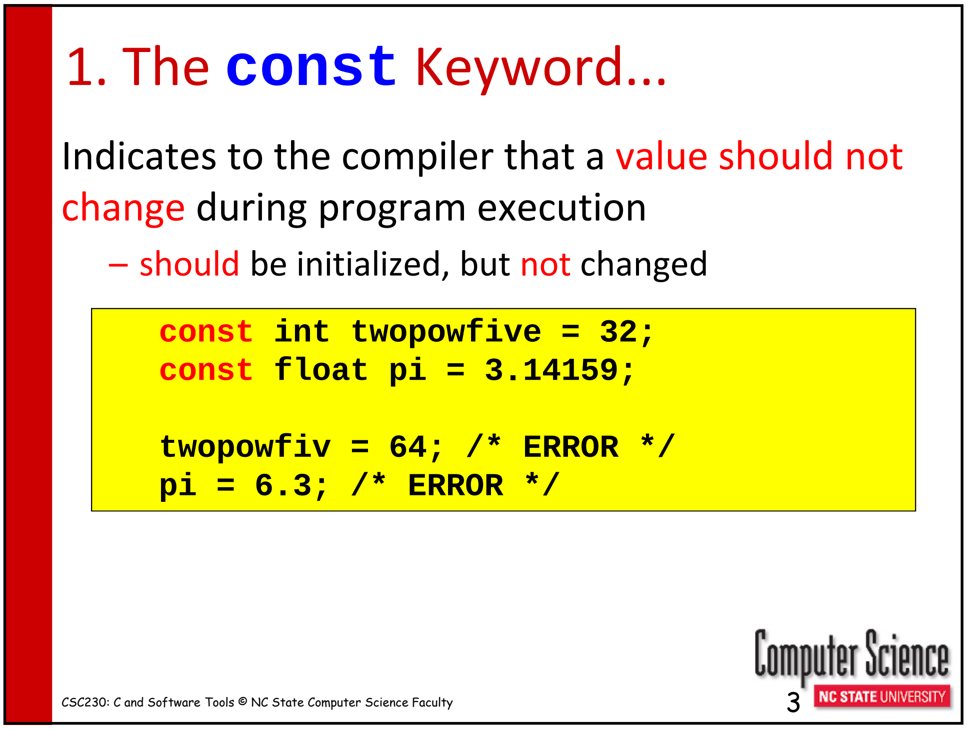
The Rest of C

C Programming and Software Tools

N.C. State Department of Computer Science

Outline

1. const
2. enum
3. typedef
4. bool
5. union
6. functions with variable # of arguments
7. environment variables
8. bit fields



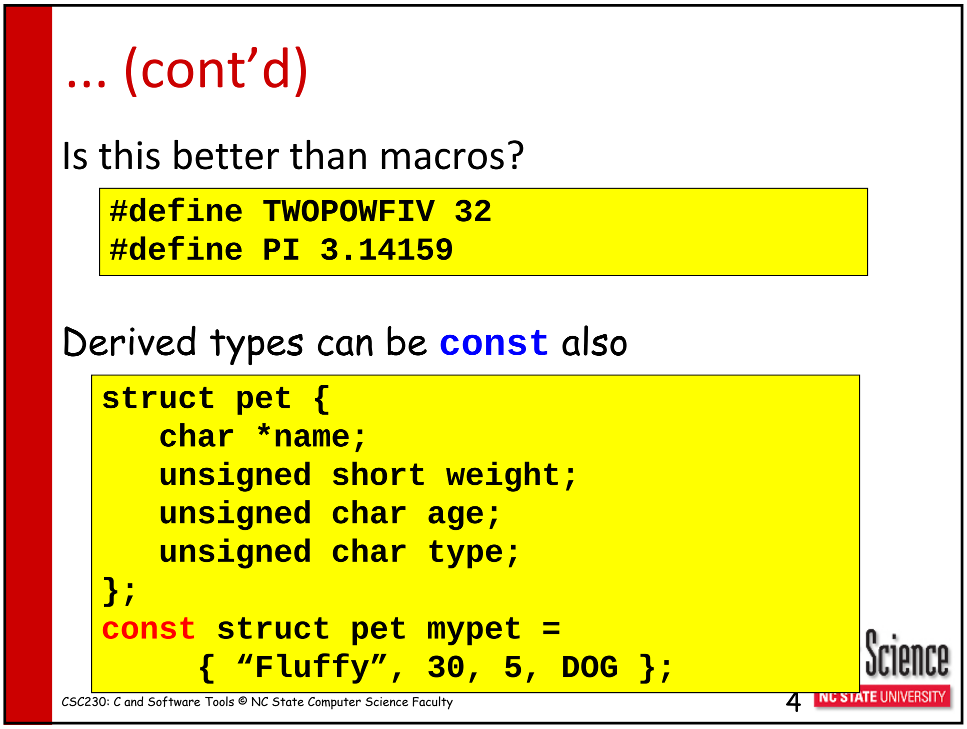
1. The const Keyword…

Indicates to the compiler that a value should not change during program execution

- should be initialized, but not changed

```
const int twopowfive = 32;
const float pi = 3.14159;

twopowfiv = 64; /* ERROR */
pi = 6.3; /* ERROR */
```



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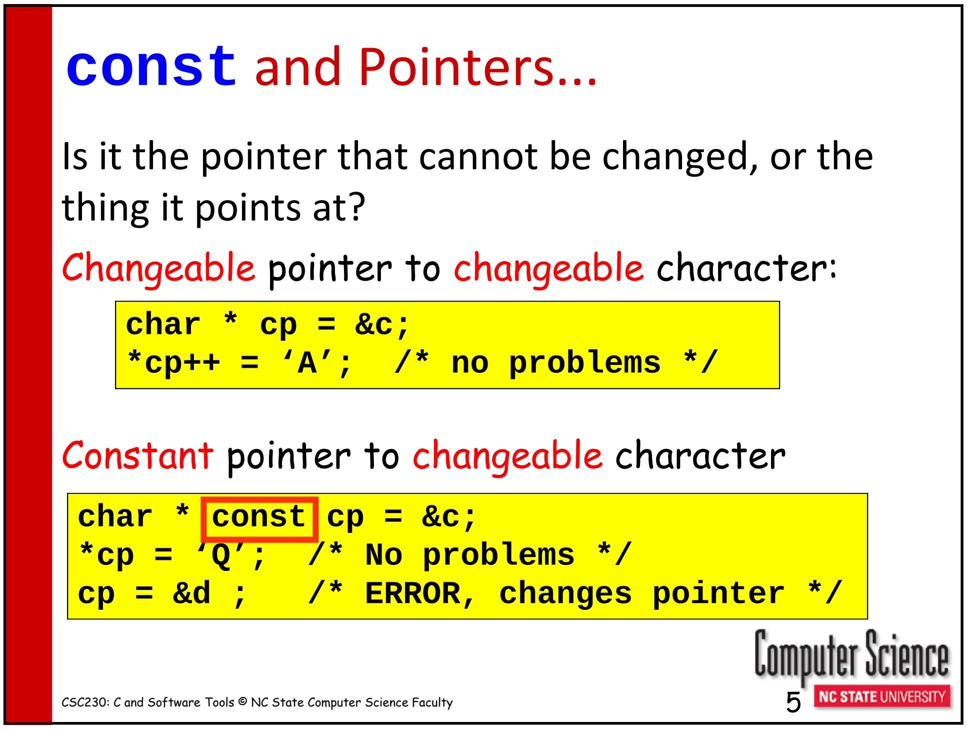
Is this better than macros?

```
#define TWOPOWFIV 32
#define PI 3.14159
```

Derived types can be const also

```
struct pet {
   char *name;
   unsigned short weight;
   unsigned char age;
   unsigned char type;
};
const struct pet mypet =
     { “Fluffy”, 30, 5, DOG };
```



const and Pointers…

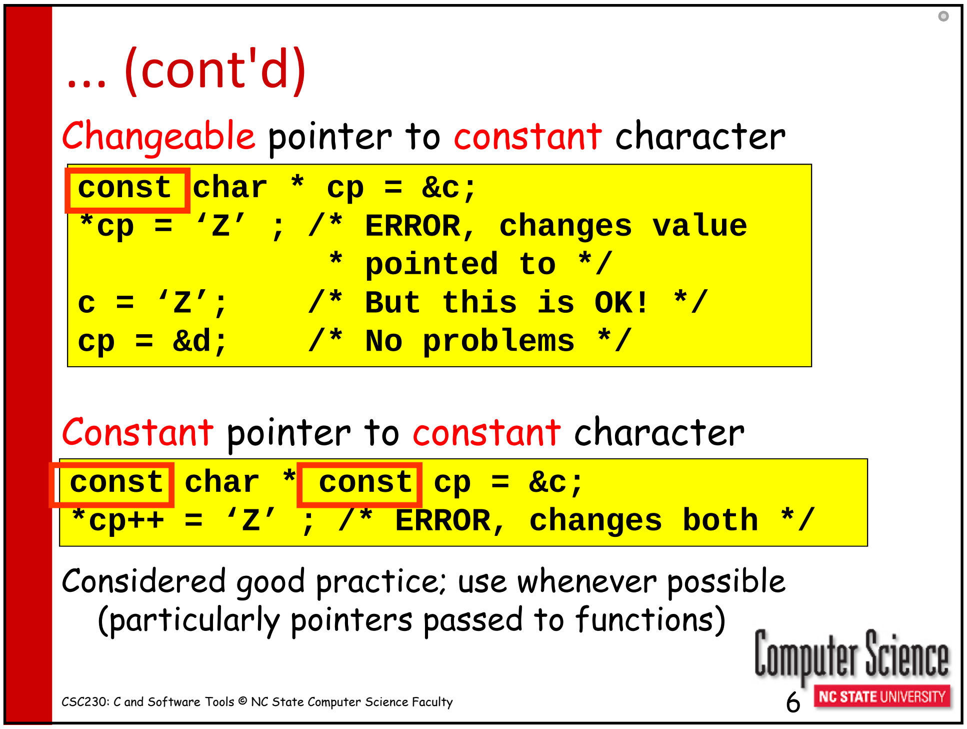
Is it the pointer that cannot be changed, or the thing it points at?

Changeable pointer to changeable character:

```
char * cp = &c;
*cp++ = ‘A’;  /* no problems */
```

Constant pointer to changeable character

```
char * const cp = &c;
*cp = ‘Q’;  /* No problems */
cp = &d ;   /* ERROR, changes pointer */
```



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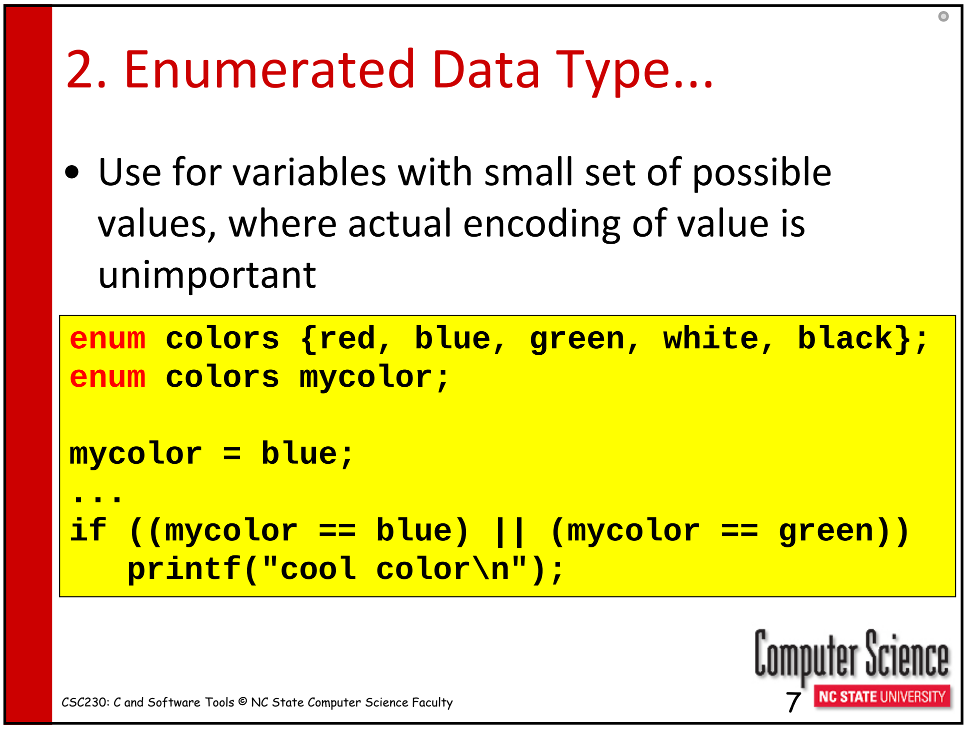
Changeable pointer to constant character

```
const char * cp = &c;
*cp = ‘Z’ ; /* ERROR, changes value
             * pointed to */
c = ‘Z’;    /* But this is OK! */
cp = &d;    /* No problems */
```

Constant pointer to constant character

```
const char * const cp = &c;
*cp++ = ‘Z’ ; /* ERROR, changes both */
```

Considered good practice; use whenever possible (particularly pointers passed to functions)

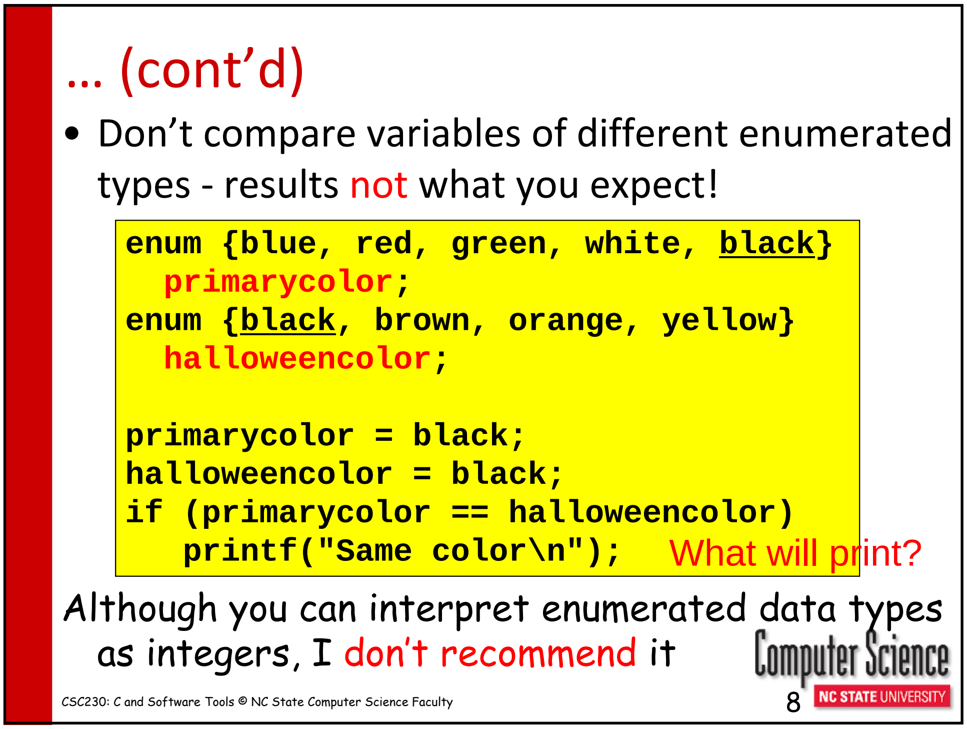


2. Enumerated Data Type…

- Use for variables with small set of possible values, where actual encoding of value is unimportant

```
enum colors {red, blue, green, white, black};
enum colors mycolor;

mycolor = blue;
...
if ((mycolor == blue) || (mycolor == green))
   printf("cool color\n");
```



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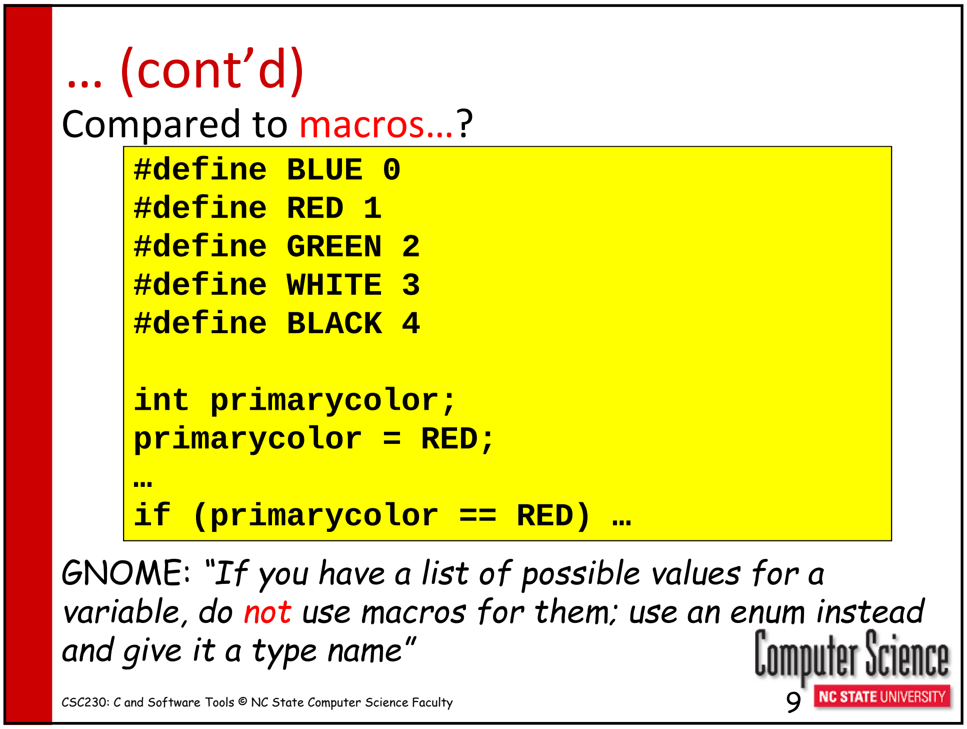
- Don't compare variables of different enumerated types - results not what you expect!

```
enum {blue, red, green, white, black}
  primarycolor;
enum {black, brown, orange, yellow}
  halloweencolor;

primarycolor = black;
halloweencolor = black;
if (primarycolor == halloweencolor)
   printf("Same color\n");
```

What will print?

Although you can interpret enumerated data types as integers, I don't recommend it



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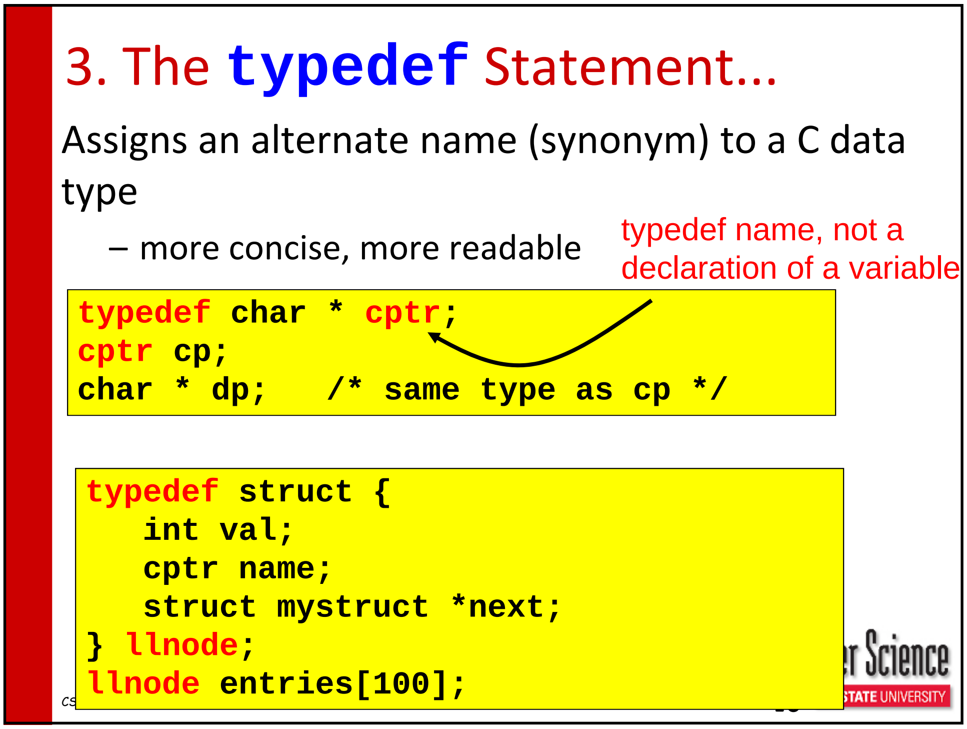
Compared to macros…?

```
#define BLUE 0
#define RED 1
#define GREEN 2
#define WHITE 3
#define BLACK 4

int primarycolor;
primarycolor = RED;
…
if (primarycolor == RED) …
```

GNOME: *"If you have a list of possible values for a variable, do not use macros for them; use an enum instead and give it a type name"*



3. The typedef Statement…

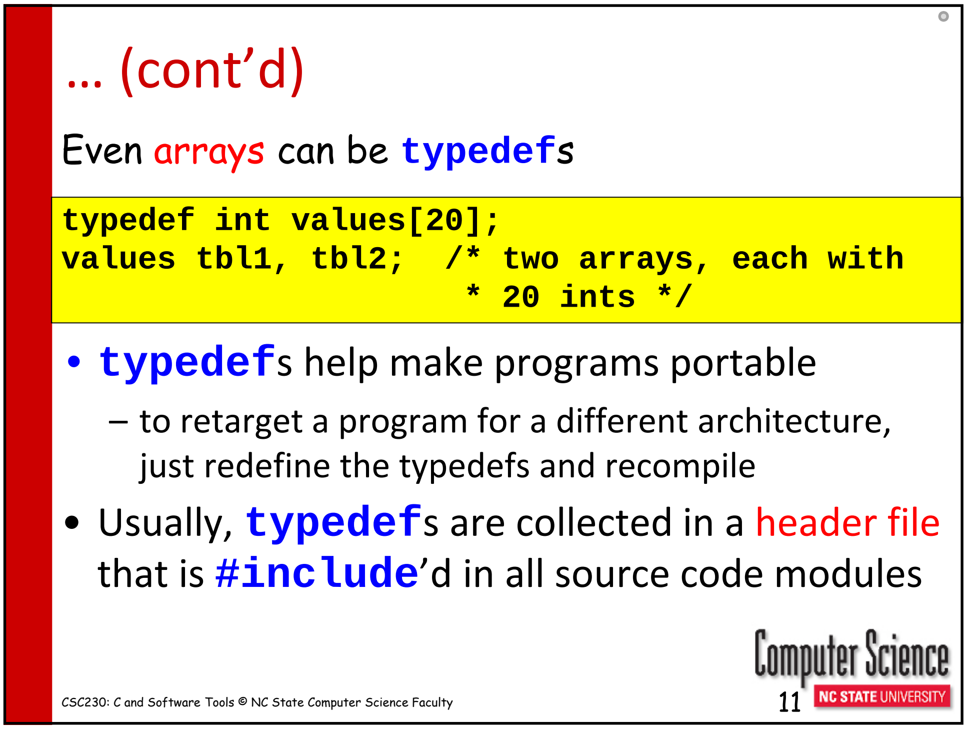
Assigns an alternate name (synonym) to a C data type

- more concise, more readable

typedef name, not a declaration of a variable

```
typedef char * cptr;
cptr cp;
char * dp;    /* same type as cp */
```

```
typedef struct {
   int val;
   cptr name;
   struct mystruct *next;
} llnode;
llnode entries[100];
```



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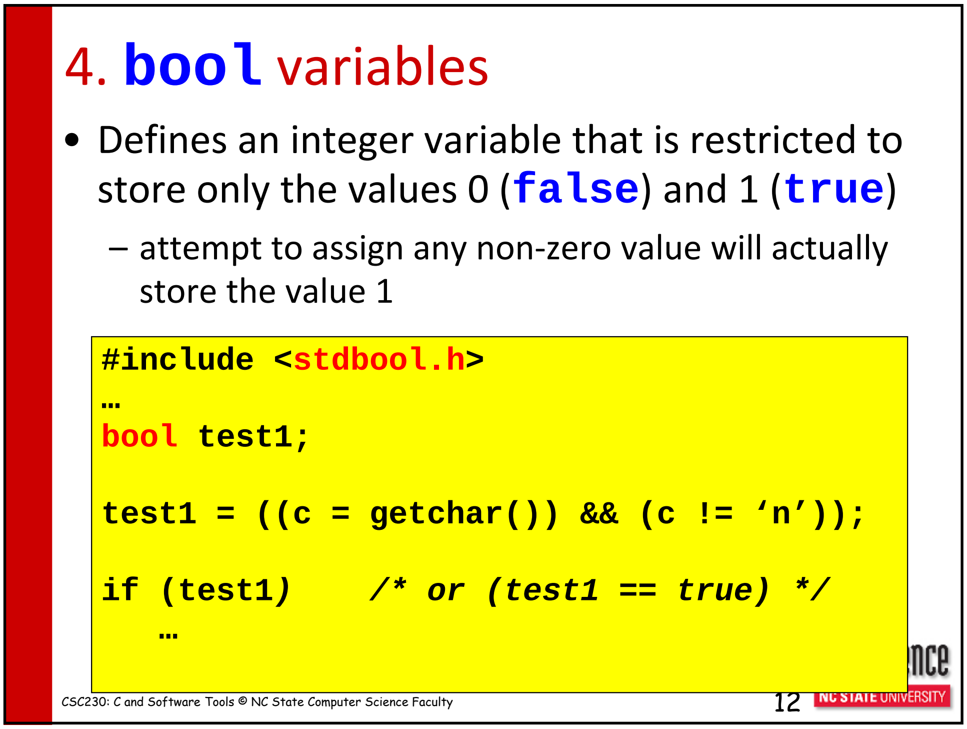
Even arrays can be **typedef**s

```
typedef int values[20];
values tbl1, tbl2;  /* two arrays, each with
                     * 20 ints */
```

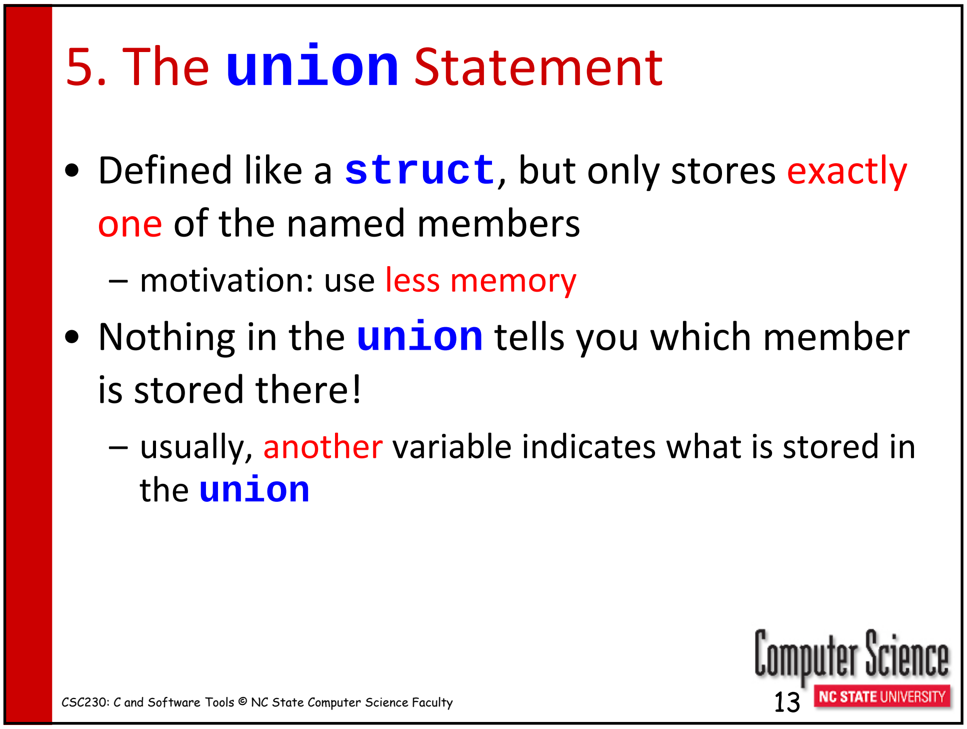
- **typedef**s help make programs portable
  - to retarget a program for a different architecture, just redefine the typedefs and recompile
- Usually, **typedef**s are collected in a header file that is **#include**'d in all source code modules



4. **bool** variables

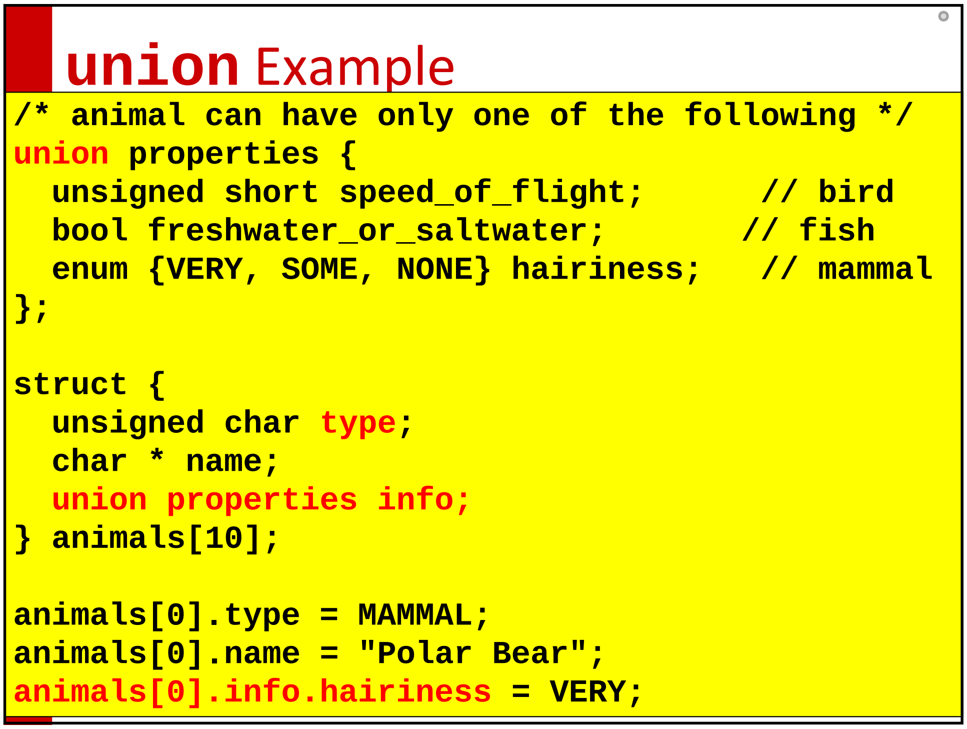
- Defines an integer variable that is restricted to store only the values 0 (**false**) and 1 (**true**)
  - attempt to assign any non-zero value will actually store the value 1

```
#include <stdbool.h>
…
bool test1;

test1 = ((c = getchar()) && (c != ‘n’));

if (test1)    /* or (test1 == true) */
   …
```



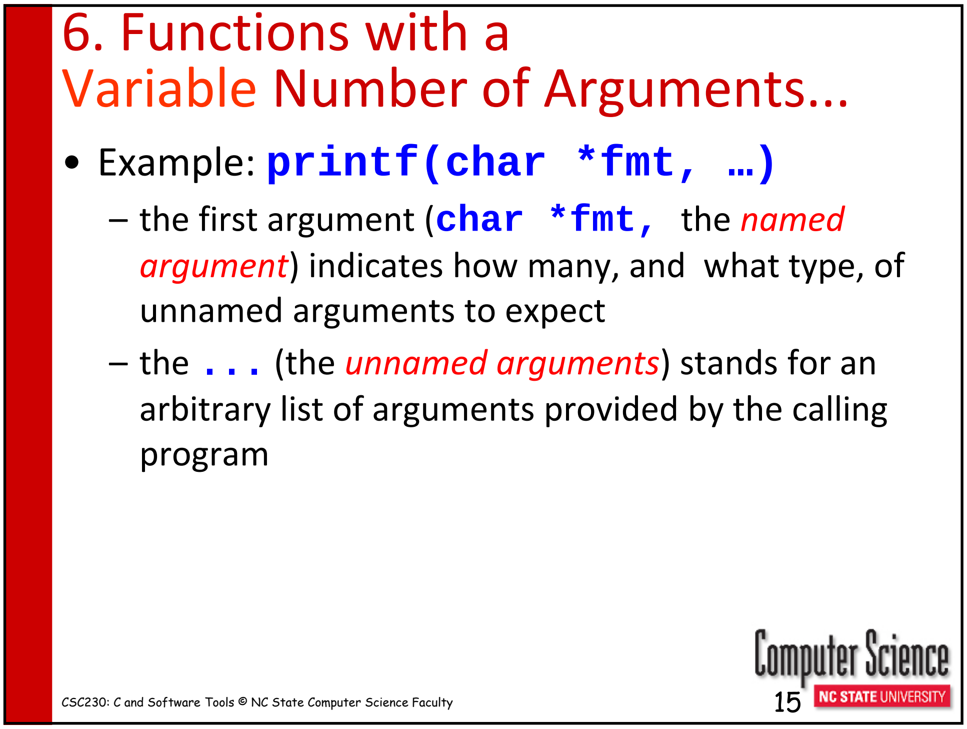
5. The union Statement

- Defined like a **struct**, but only stores exactly one of the named members
  - motivation: use less memory
- Nothing in the **union** tells you which member is stored there!
  - usually, another variable indicates what is stored in the **union**



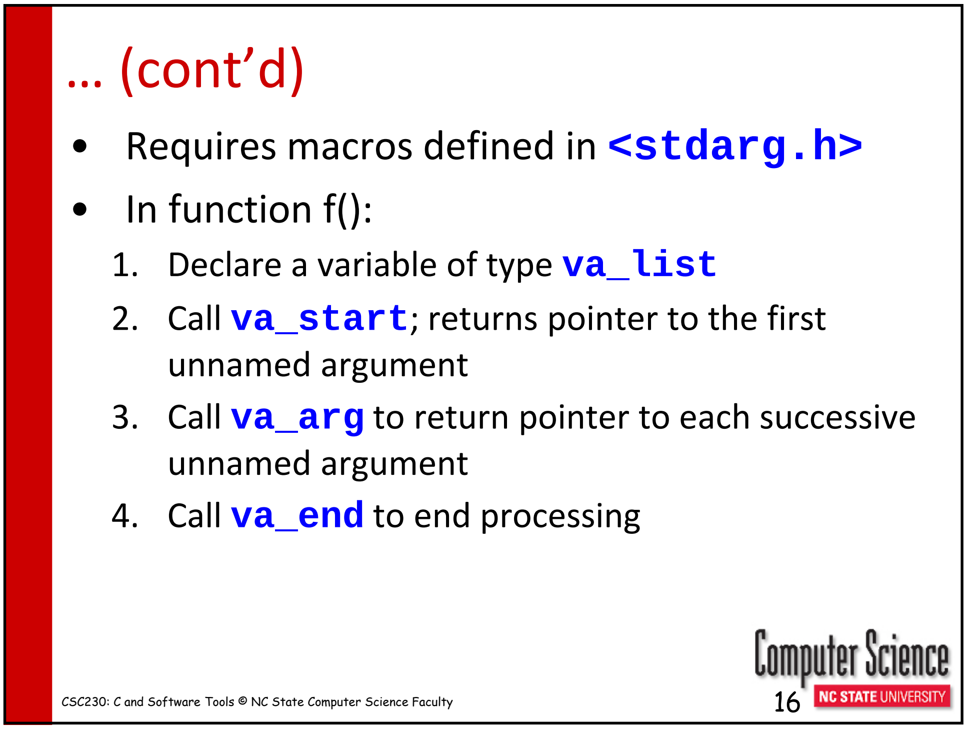
union Example

```
/* animal can have only one of the following */
union properties {
  unsigned short speed_of_flight;      // bird
  bool freshwater_or_saltwater;       // fish
  enum {VERY, SOME, NONE} hairiness;   // mammal
};

struct {
  unsigned char type;
  char * name;
  union properties info;
} animals[10];

animals[0].type = MAMMAL;
animals[0].name = "Polar Bear";
animals[0].info.hairiness = VERY;
```



6. Functions with a Variable Number of Arguments...

- Example: `printf(char *fmt, …)`
  - the first argument (`char *fmt,` the *named argument*) indicates how many, and what type, of unnamed arguments to expect
  - the `...` (the *unnamed arguments*) stands for an arbitrary list of arguments provided by the calling program



… (cont'd)

- Requires macros defined in `<stdarg.h>`
- In function f():
  1. Declare a variable of type `va_list`
  2. Call `va_start`; returns pointer to the first unnamed argument
  3. Call `va_arg` to return pointer to each successive unnamed argument
  4. Call `va_end` to end processing

… (cont'd)

- How many unnamed parameters?
  - this has to be indicated by the named parameter
- What are types of unnamed parameters?
  - either this is fixed (implicit), or the named parameter must explicitly indicate
  - example: the `printf()` format specifier

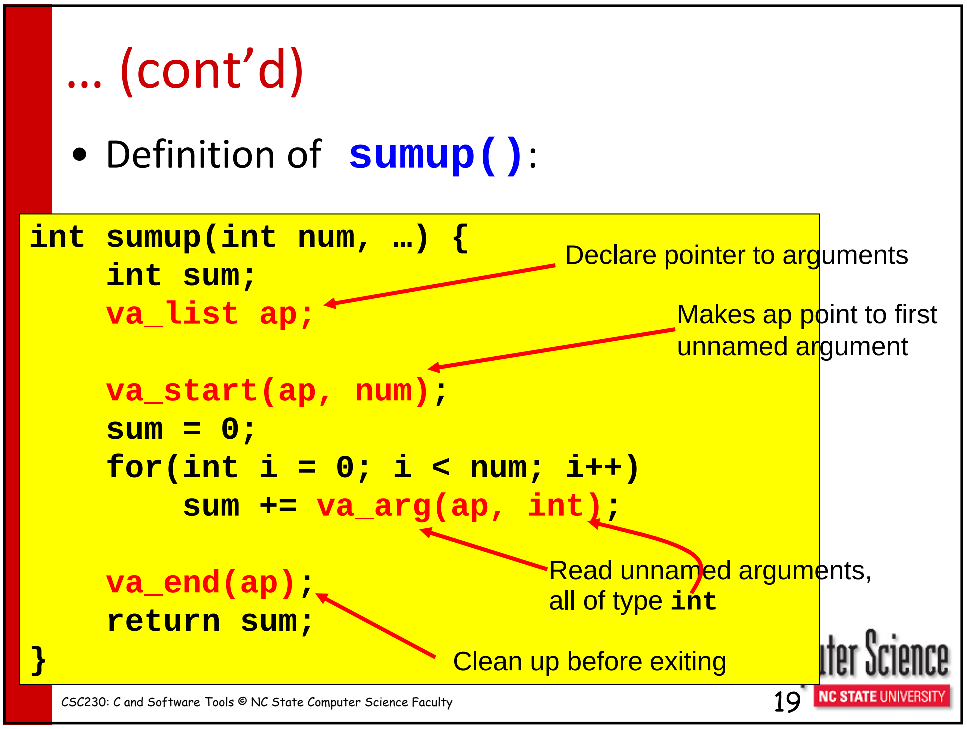
Example...

- A function `sumup(num, …)` which returns the sum of a list of `num` arguments, all of type `int`
- Calling `sumup()`:

```
#include <stdio.h>
#include <stdarg.h>
int sumup(int, …);

int main(void)
{
   int i = 295, j = 3, k = 450, res;
   res = sumup(3, i, j, k);
   …
}
```

List of unnamed arguments

Number of unnamed arguments



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- Definition of **sumup()**:

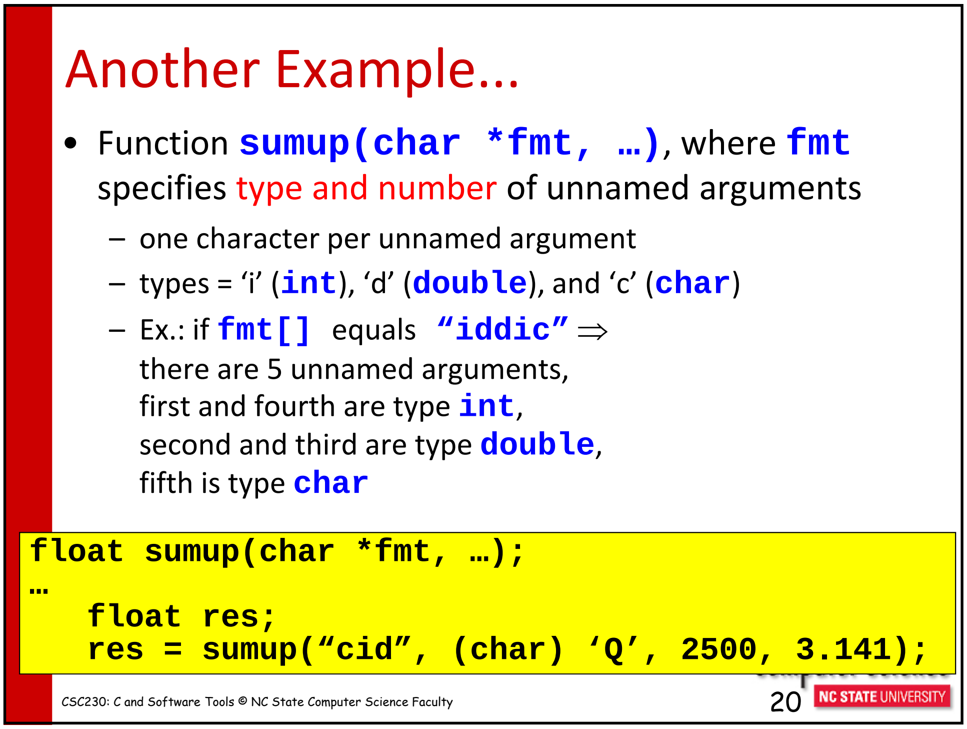
```
int sumup(int num, …) {
    int sum;
    va_list ap;

    va_start(ap, num);
    sum = 0;
    for(int i = 0; i < num; i++)
        sum += va_arg(ap, int);

    va_end(ap);
    return sum;
}
```

Declare pointer to arguments

Makes ap point to first unnamed argument

Read unnamed arguments, all of type `int`

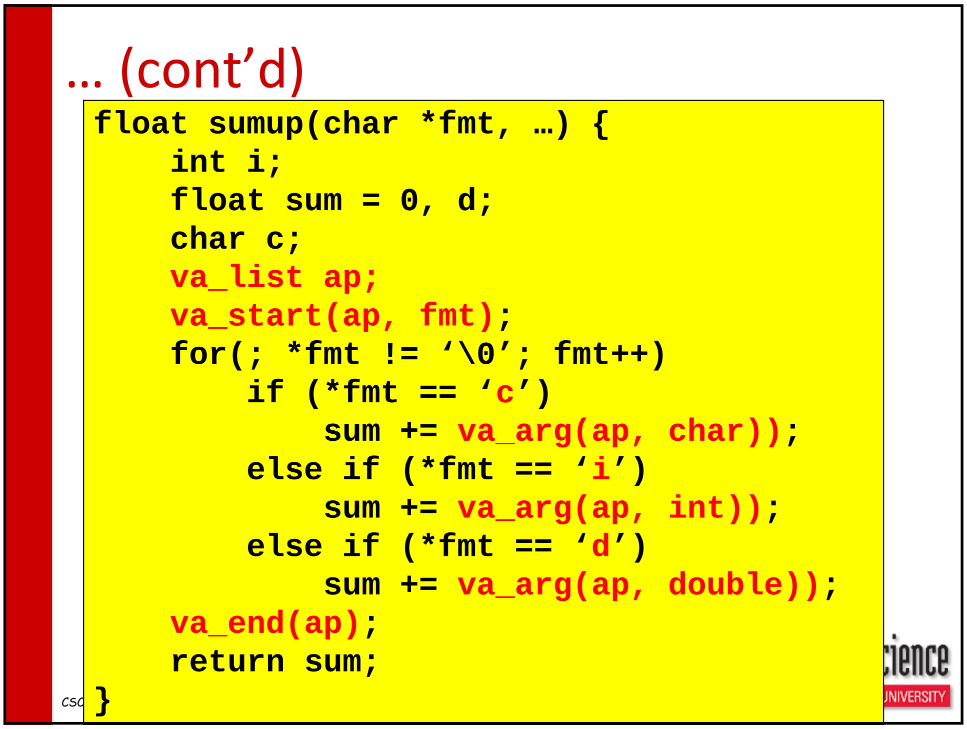
Clean up before exiting



Another Example…

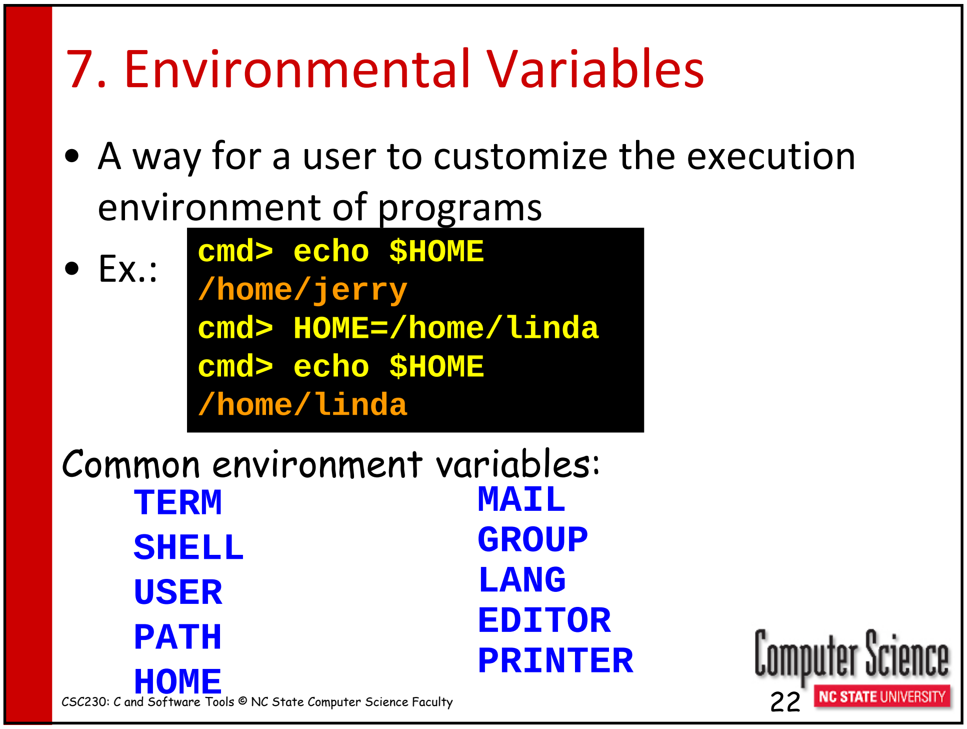
- Function **sumup(char *fmt, …)**, where **fmt** specifies type and number of unnamed arguments
  - one character per unnamed argument
  - types = ‘i’ (**int**), ‘d’ (**double**), and ‘c’ (**char**)
  - Ex.: if **fmt[]** equals **“iddic”** ⇒ there are 5 unnamed arguments,
    first and fourth are type **int**,
    second and third are type **double**,
    fifth is type **char**

```
float sumup(char *fmt, …);
…
   float res;
   res = sumup(“cid”, (char) ‘Q’, 2500, 3.141);
```



… (cont’d)

```
float sumup(char *fmt, …) {
    int i;
    float sum = 0, d;
    char c;
    va_list ap;
    va_start(ap, fmt);
    for(; *fmt != ‘\0’; fmt++)
        if (*fmt == ‘c’)
            sum += va_arg(ap, char));
        else if (*fmt == ‘i’)
            sum += va_arg(ap, int));
        else if (*fmt == ‘d’)
            sum += va_arg(ap, double));
    va_end(ap);
    return sum;
}
```



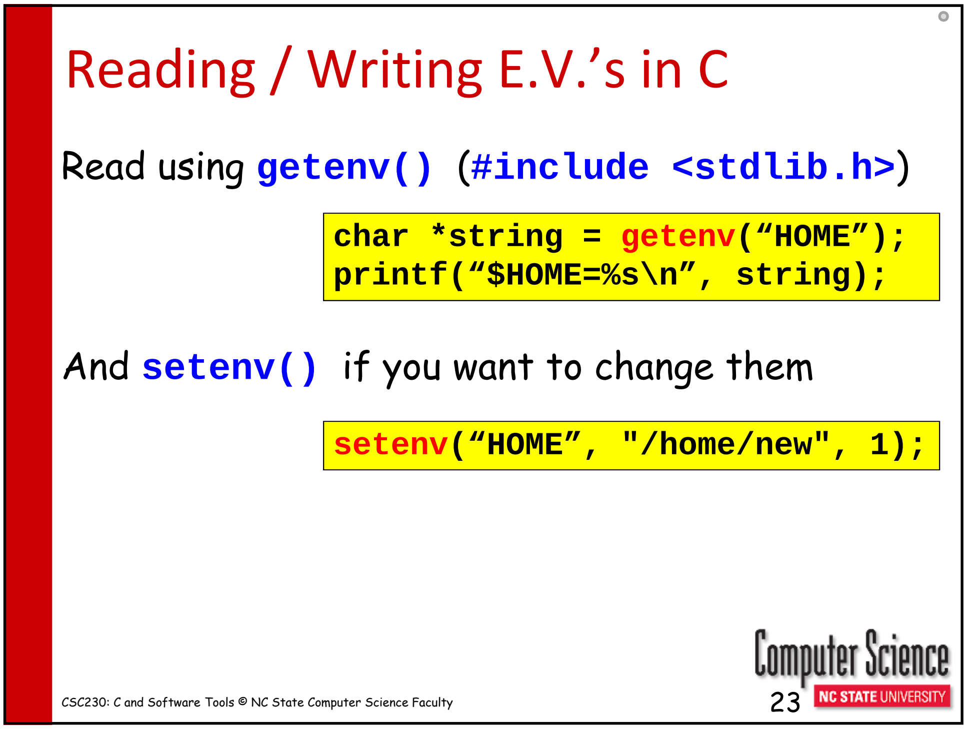
7. Environmental Variables

- A way for a user to customize the execution environment of programs
- Ex.:

```
cmd> echo $HOME
/home/jerry
cmd> HOME=/home/linda
cmd> echo $HOME
/home/linda
```

Common environment variables:

TERM
SHELL
USER
PATH
HOME
MAIL
GROUP
LANG
EDITOR
PRINTER



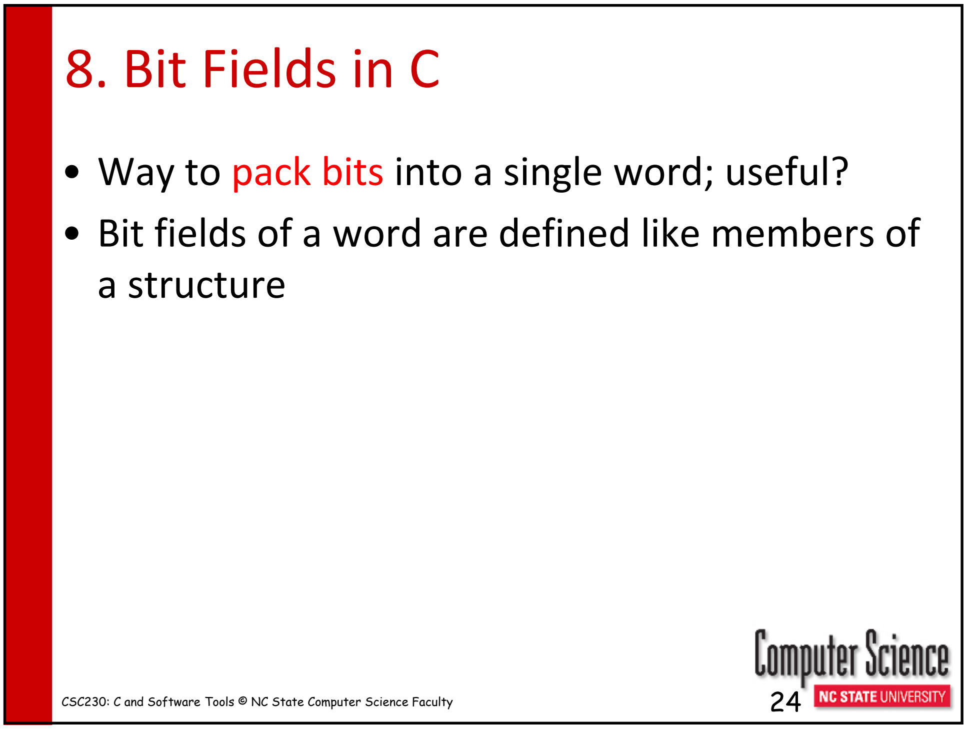
Reading / Writing E.V.’s in C

Read using `getenv()` (`#include <stdlib.h>`)

```
char *string = getenv(“HOME”);
printf(“$HOME=%s\n”, string);
```

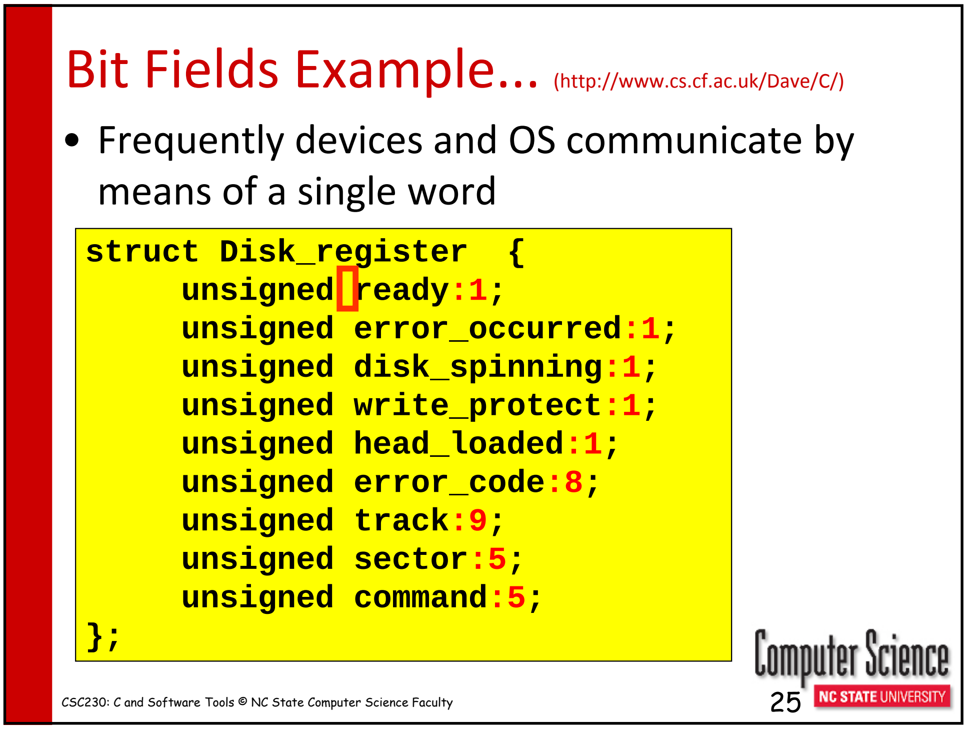
And `setenv()` if you want to change them

```
setenv(“HOME”, "/home/new", 1);
```



8. Bit Fields in C

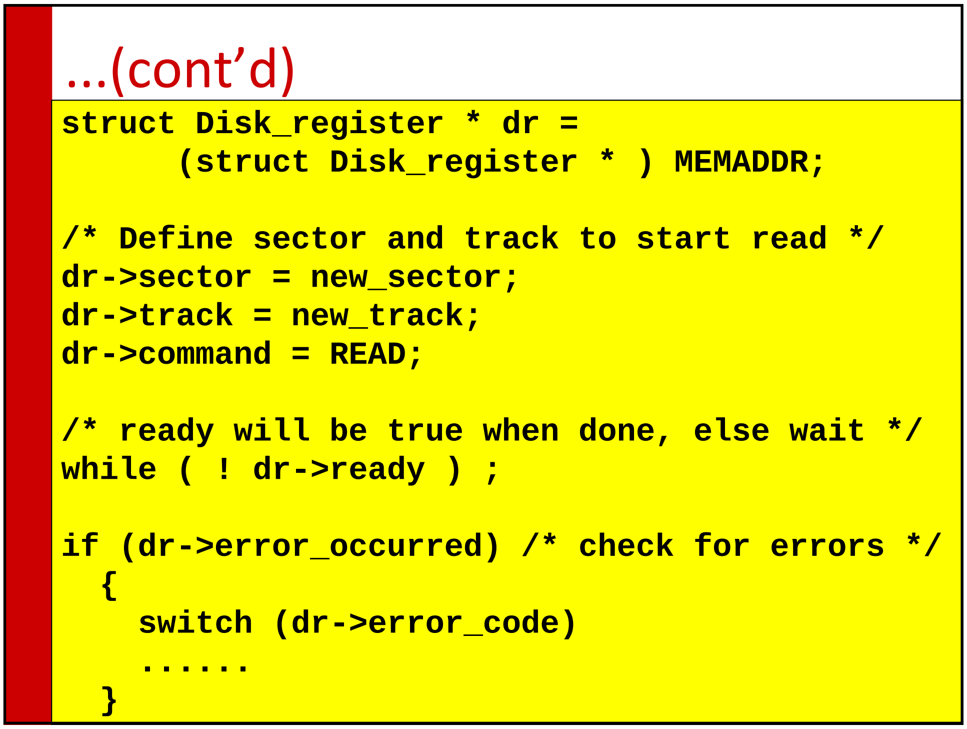
- Way to pack bits into a single word; useful?
- Bit fields of a word are defined like members of a structure



Bit Fields Example... (http://www.cs.cf.ac.uk/Dave/C/)

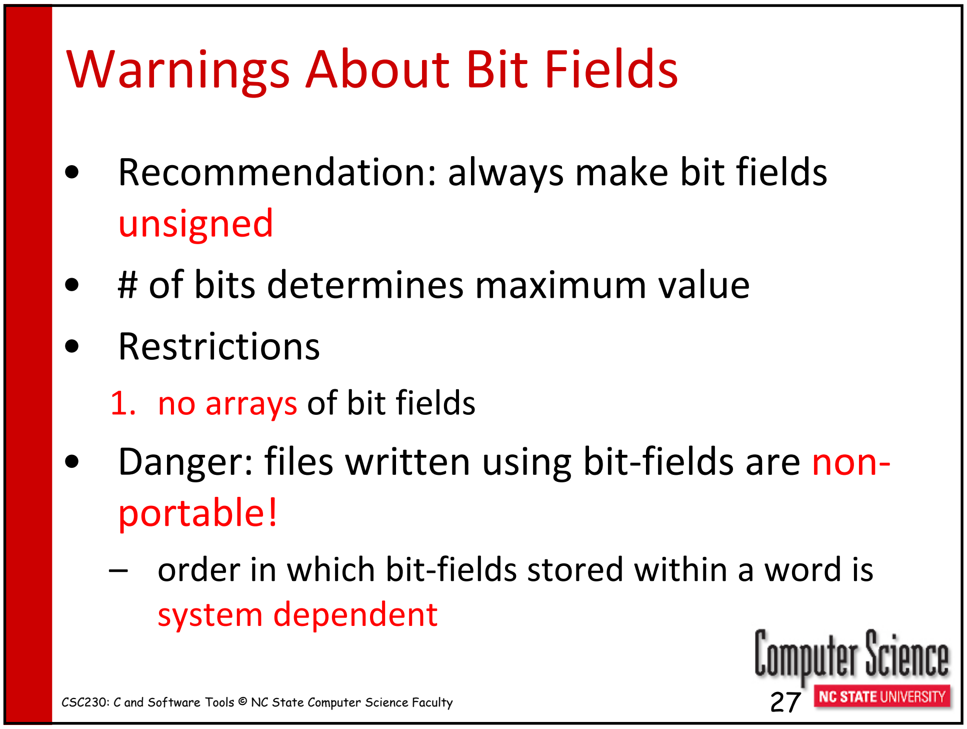
- Frequently devices and OS communicate by means of a single word

```
struct Disk_register  {
     unsigned ready:1;
     unsigned error_occurred:1;
     unsigned disk_spinning:1;
     unsigned write_protect:1;
     unsigned head_loaded:1;
     unsigned error_code:8;
     unsigned track:9;
     unsigned sector:5;
     unsigned command:5;
};
```



...(cont'd)

```
struct Disk_register * dr =
      (struct Disk_register * ) MEMADDR;

/* Define sector and track to start read */
dr->sector = new_sector;
dr->track = new_track;
dr->command = READ;

/* ready will be true when done, else wait */
while ( ! dr->ready ) ;

if (dr->error_occurred) /* check for errors */
  {
    switch (dr->error_code)
    ......
  }
```



Warnings About Bit Fields

- Recommendation: always make bit fields unsigned
- # of bits determines maximum value
- Restrictions
  1. no arrays of bit fields
- Danger: files written using bit-fields are non-portable!
  - order in which bit-fields stored within a word is system dependent