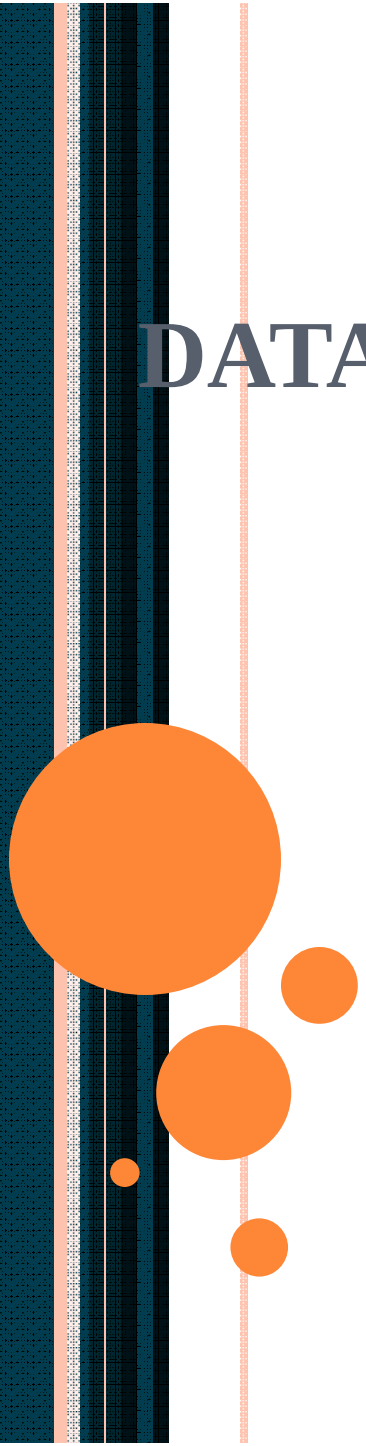
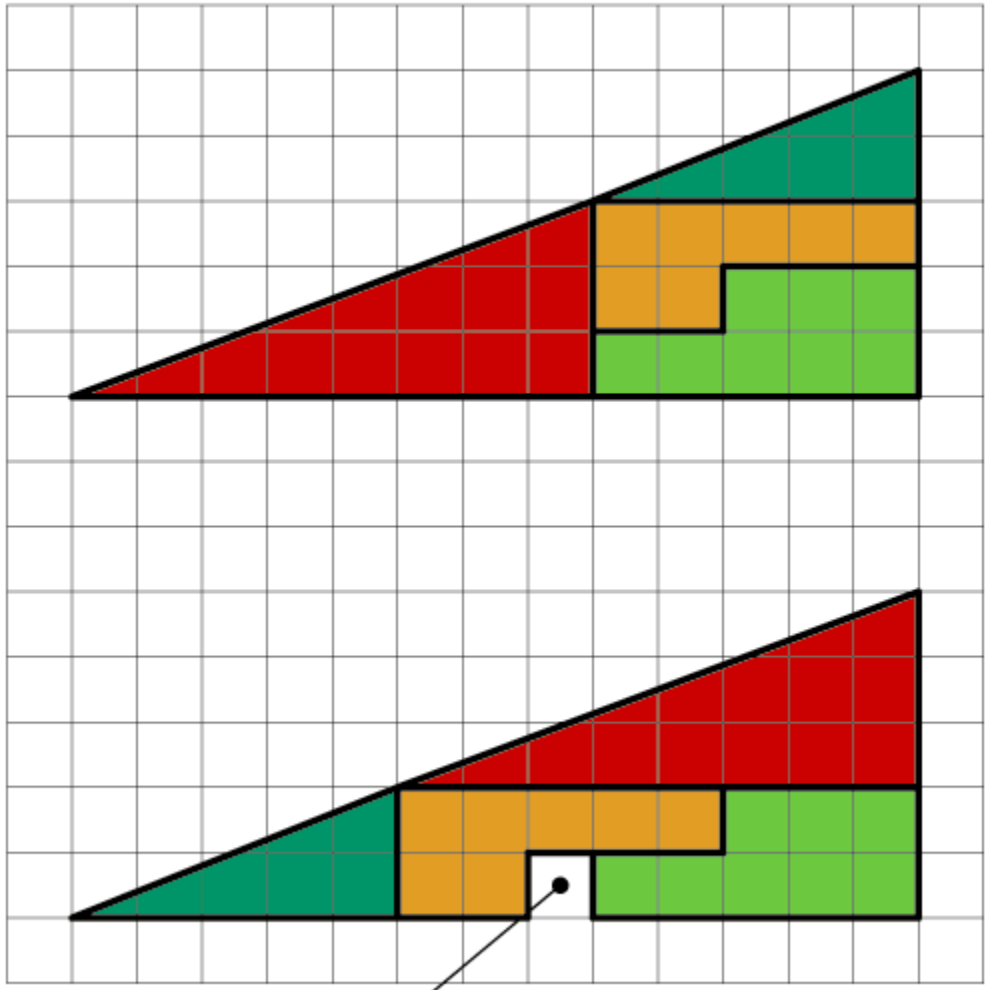
DATA STRUCTURES USING ‘C’



Review: Records

HOW CAN THIS BE TRUE ?



Below the four parts are moved around

The partitions are exactly the same, as those used above

From where comes this "hole" ?

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Records Within R

There is nothing to prevent us from placi
field within a record):

```
Date_Type definesa record
  day, month, year isoftype num
Endrecord

Student_Type definesa record
  name isoftype string
  gpa isoftype num
  birth_day isoftype Date_Type
  graduation_day isoftype Date_Type
endrecord
```

This name is now a type which can be used anywhere a type such as "Num" can be used.

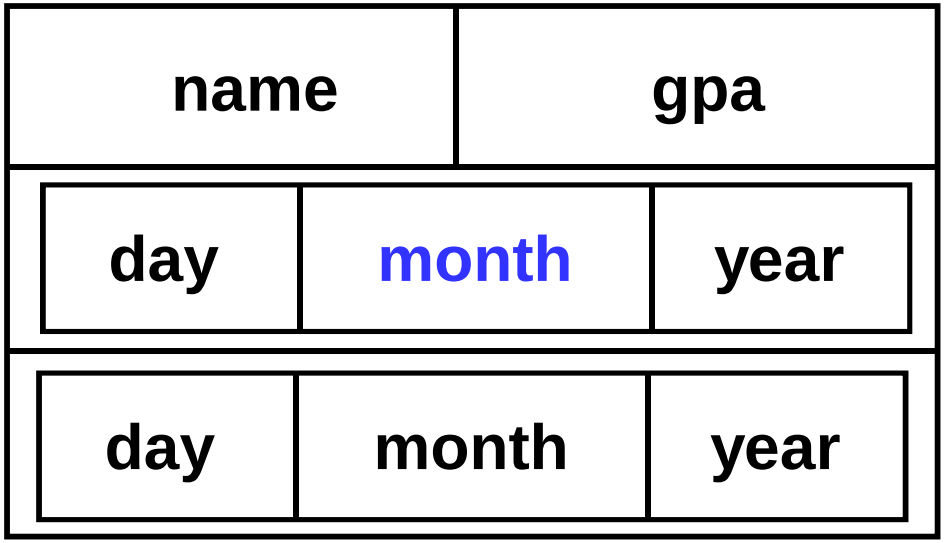
What are these called?

Types

Record Within Records

Date_Type:

Student_Type:




```
bob isoftype Student_Type
bob.birth_day.month <- 6
```

Types vs. Variables

- **TYPE Definitions**
  - Create templates for new kinds of variables
  - Do not create a variable – no storage space is allocated
  - Have unlimited scope

- **VARIABLE Declarations**
  - Actually create storage space
  - Have limited scope - only module containing the variable can “see” it
  - Must be based on an existing data type

Dynamic Memory and Pointers

Dynamic vs. Static

Static (fixed in size)

- **Sometimes we create data structures that are "fixed" and don't need to grow or shrink.**

Dynamic (change in size)

- **Other times, we want the ability to increase and decrease the size of our data structures to accommodate changing needs.**

Static Data

- **Static data is data declared "ahead of time."**
- **It is declared in a module (or main algorithm) and "lives" for as long as that module is active.**
- **If we declare more static variables than we need, we waste space.**
- **If we declare fewer static variables than we need, we are out of luck.**
- **Often, real world problems mean that we don't know how many variables to declare, as the number needed will change over time.**

Dynamic Data

- **Dynamic data refers to data structures which can grow and shrink to fit changing data requirements.**
- **We can allocate (create) additional dynamic variables whenever we need them.**
- **We can de-allocate (kill) dynamic variables whenever we are done with them.**
- **A key advantage of dynamic data is that we can always have a exactly the number of variables required - no more, no less.**
- **For example, with pointer variables to connect them, we can use dynamic data structures to create a chain of data structures called a linked list.**

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Note

- **Dynamic data gives us more flexibility**
- **Memory is still limited**
- **But now we can use it where we need it**
- **And we can determine that while the program is running**

Examples?

Printer Queues
Airliners
uh, everything?

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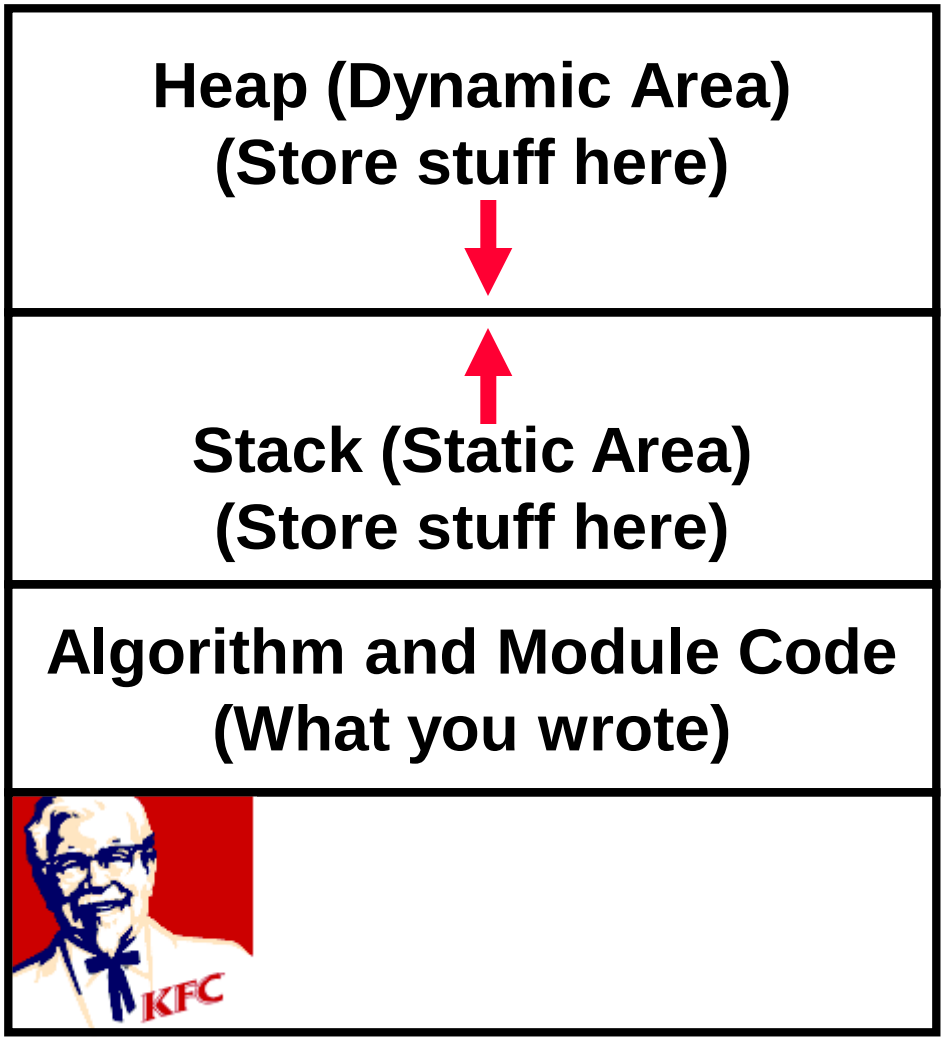
A View of Memory



A List Example

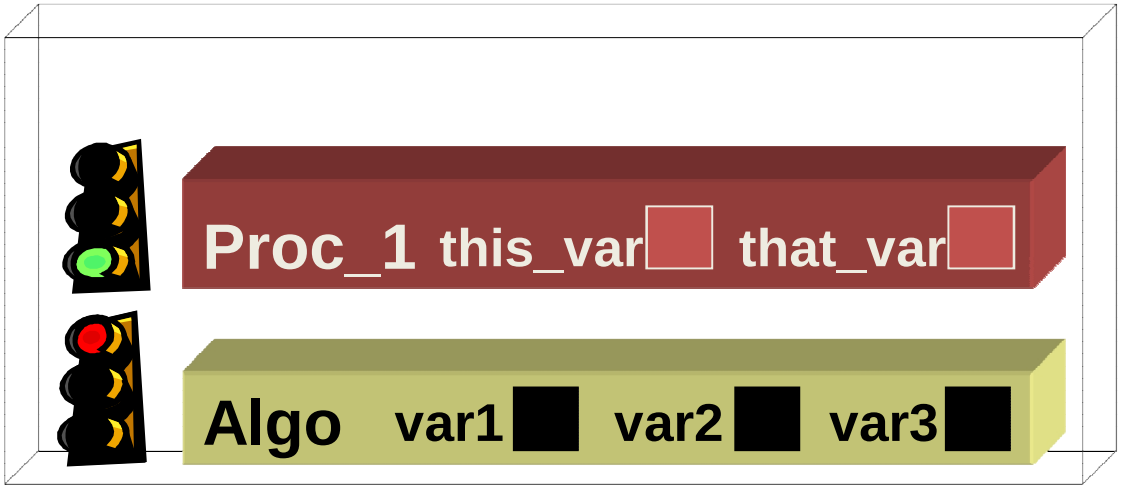
- **We must maintain a list of data**
- **Sometimes we want to use only a little memory:**

- **Sometimes we need to use more memory**

- **Declaring variables in the standard way won't work here because we don't know how many variables to declare**
- **We need a way to allocate and de-allocate data dynamically (i.e., on the fly)**

The Stack

- **Recall the activation stack**
  - **The stack can expand, but as for the data…**
  - **Each frame contains static (fixed size) data**



The number of variables needed come from the "isoftype" statements.

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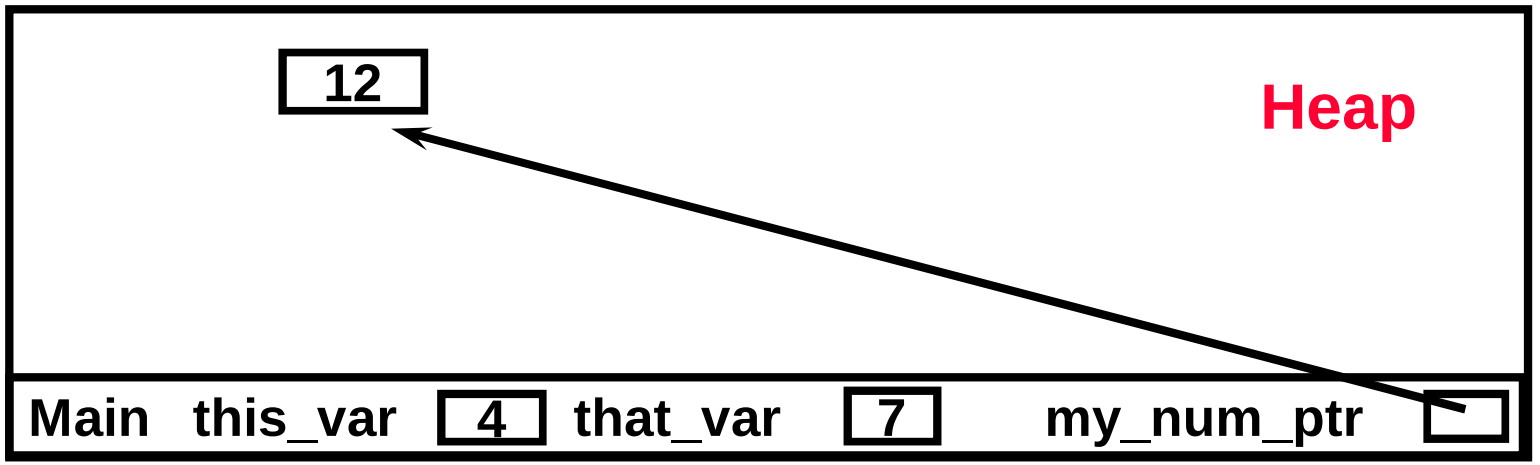
The Stack and Heap



Stack

- The **heap** is memory not used by the **stack**
- As **stack** grows, **heap** shrinks
- **Static** variables live in the **stack**
- **Dynamic** variables live in the **heap**

What kind of variable is this???

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What?

- **We know (sort of) how to get a pointer variable**

```
my_num_ptr isoftype Ptr toa Num
```

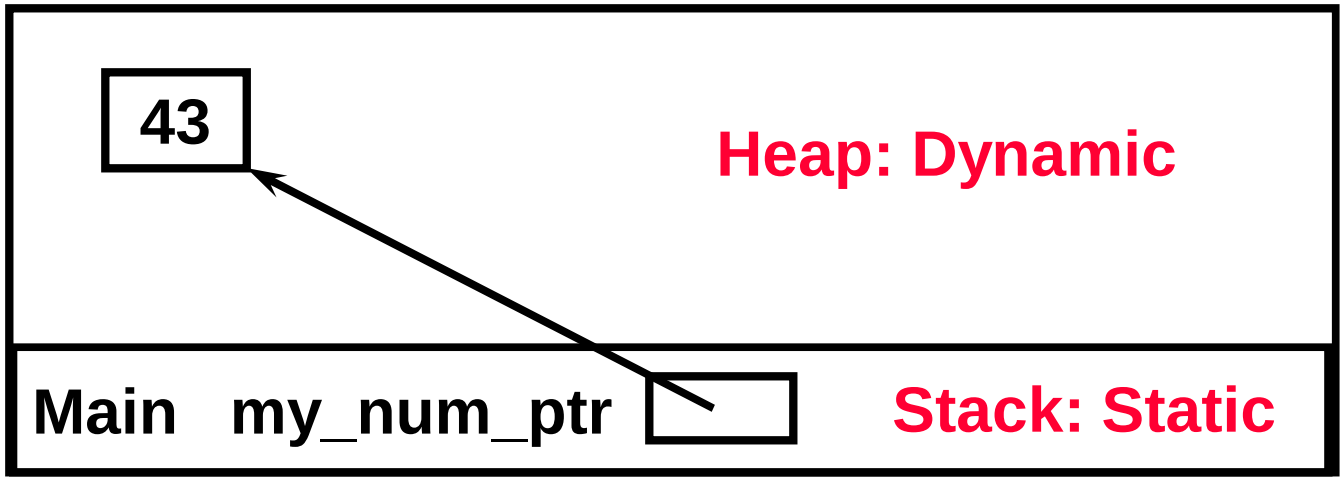
- **But how do we get it to point at something?**

The Built-In Function NEW()

- **Takes a type as a parameter**
- **Allocates memory in the heap for the type**
- **Returns a pointer to that memory**

```
my_num_ptr <- new(Num)
dynamic_string <- new(String)
list_head <- new(Node)
```

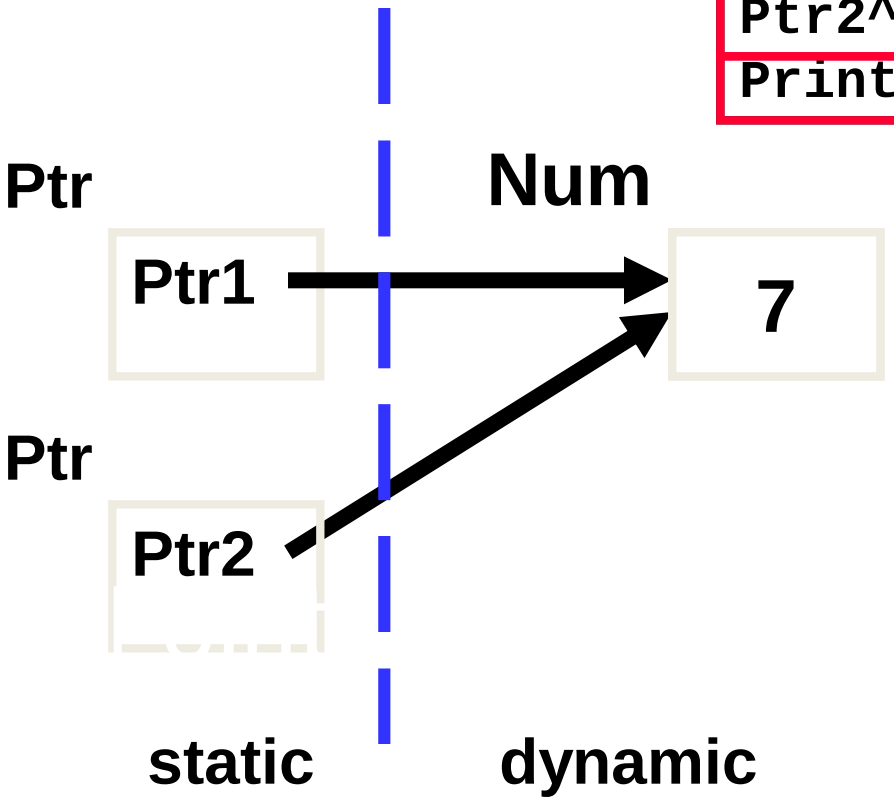
Accessing Dynamic Data via Pointers



- **When we "follow a pointer", we say that we dereference that pointer**
- **The carat (^) means "dereference the pointer"**
- **`my_num_ptr^` means "follow my_num_ptr to wherever it points"**
- **`My_num_ptr^ <- 43` is valid**

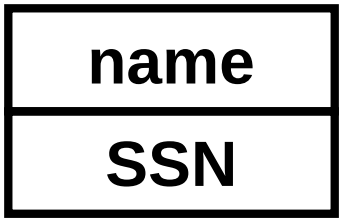
```
Ptr1 isoftype Ptr toa Num
Ptr2 isoftype Ptr toa Num
Ptr1 <- new(Num)
Ptr1^ <- 5
Ptr2 <- Ptr1
Print(Ptr1^, Ptr2^)
Ptr2^ <- 7
Print(Ptr1^, Ptr2^)
```

```
5  5
7  7
```



A record to hold two items of data - a name and a SSN:

```
Student definesa record
  name isoftype String
  SSN isoftype num
endrecord
```



And a pointer to a Student record:

```
current isoftype ptr toa Student
current <- new(Student)
```