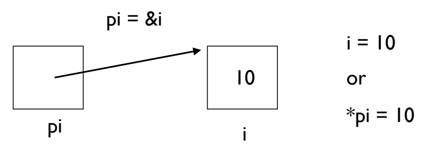
Data Structure:
Dynamic memory allocation

chap. 1.2, 2.1-2.3

int vs. pointer-to-int

int i, *pi



"i" is a variable of an integer

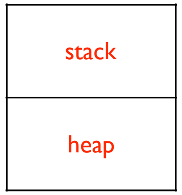
"pi" is a variable of a pointer to an integer (address)

"&i" returns the address of variable i

"*pi" returns an integer value in the address pi

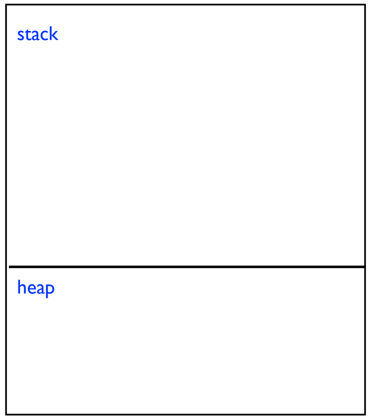
program execution in memory

- data space consists of the stack and the heap
- the stack is used to store statically declared data
  - variables with names
  - data declared before compilation
  - access via their identifiers
- the heap is used to store dynamically allocated data
  - storage without names
  - get it when you need it
  - access by following pointers
  - by memory allocation function such as malloc



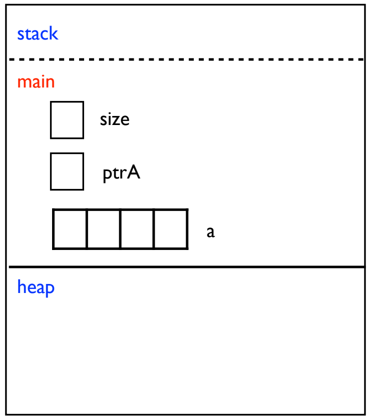
allocating and freeing dynamic data

```
main()
{
     int a[4];
     int *ptrA;
     int size;
}
```



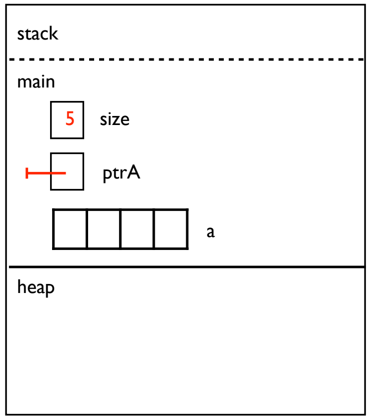
allocating and freeing dynamic data

```
main()
{
    int a[4];
    int *ptrA;
    int size;
}
```



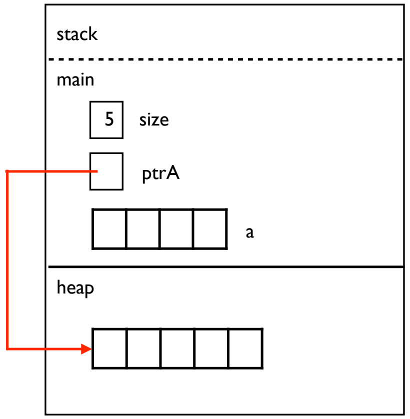
allocating and freeing dynamic data

```
main()
{
    int a[4];
    int *ptrA;
    int size;

    size = 5;
    ptrA = NULL;
}
```



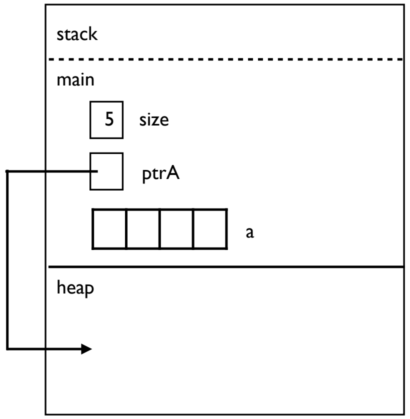
allocating and freeing dynamic data

```
main()
{
    int a[4];
    int *ptrA;
    int size;

    size = 5;
    ptrA = NULL;

    ptrA = (int *) malloc(size * sizeof(int));
}
```



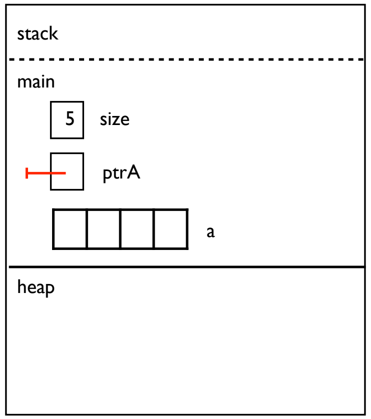
allocating and freeing dynamic data

```
main()
{
    int a[4];
    int *ptrA;
    int size;

    size = 5;
    ptrA = NULL;

    ptrA = (int *) malloc(size * sizeof(int));

    free(ptrA);

}
```



allocating and freeing dynamic data

```
main()
{
    int a[4];
    int *ptrA;
    int size;

    size = 5;
    ptrA = NULL;

    ptrA = (int *) malloc(size * sizeof(int));

    free(ptrA);

    ptrA = NULL;
}
```



dynamic allocation

- void *malloc (size_t size)*
  - it returns a pointer to space for an object of size *size* or NULL if the request cannot be satisfied
  - intPtr = (int *) malloc (size * sizeof(int))
- void *realloc*(void **p*, size_t *size*)
  - it changes the size of the object pointed to by *p* to *size*
  - the contents will be unchanged up to the minimum of the old and new sizes
  - intPtr = (int *) realloc(intPtr, 50)
- void *free* (void **p*)
  - it deallocates the space pointed to by *p*
  - *p* must be a pointer to space previously allocated by *malloc*, or *realloc*

array

- Is it OK?

```
#include <stdio.h>

void main(void){

        int *list1;
        int list2[5];

        list1[0] = 34;
        list2[0] = 34;

}
```

array

- Is it OK?

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

void main(void){

        int *list1;
        int list2[5];

        list2[0] = 34;

        list1 = (int *)malloc(5*sizeof(int));

        list1[0] = 35;
        printf("%d  %d\n", list1[0], list2[0]);

}
```

structures

- Example: storing information about persons including
  - Name
  - Age
  - Height

structures

- Example: storing information about persons including
  - Name
  - Age
  - Height
- a structure is a collection of one or more variables that can be of different types
- How?
  - First, create a structure that defines a new data type
  - Second, create variable of that new type

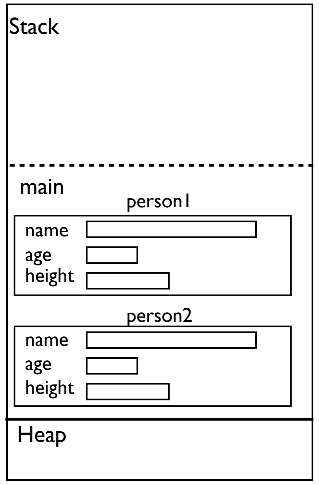
```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
```

structures

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;

main()
{
        personT person1;

        person1.name = "Brian";
        person1.age = 10;
        person1.height = 20;
}
```

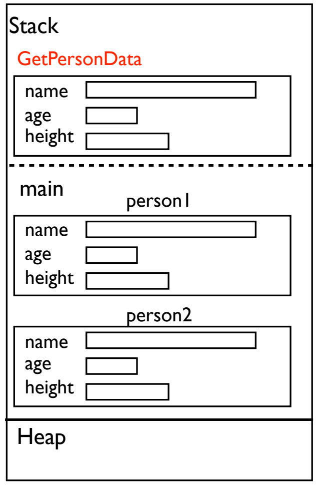
structures: passing structure

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
void GetPersonData(personT x);
main()
{
        personT person1;
        personT person2;

        GetPersonData(person1);
}

void GetPersonData (personT x){
        x.name = "Brian";
        x.age = 10;
        x.height = 20;
}
```



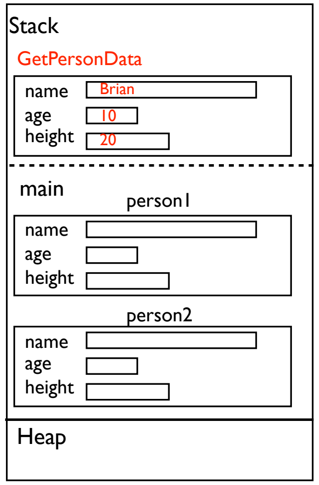
structures: passing structure

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
void GetPersonData(personT x);

main()
{
        personT person1;
        personT person2;

        GetPersonData(person1);
}

void GetPersonData (personT x){
        x.name = “Brian”;
        x.age = 10;
        x.height = 20;
}
```



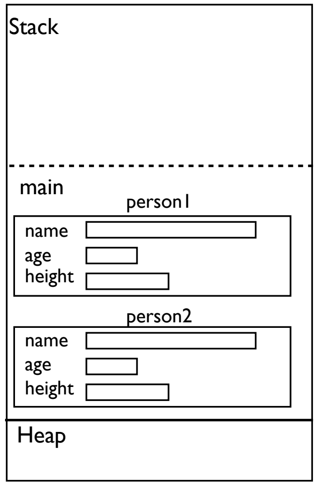
structures: passing structure

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
void GetPersonData(personT x);

main()
{
        personT person1;
        personT person2;

        GetPersonData(person1);
}

void GetPersonData (personT x){
        x.name = “Brian”;
        x.age = 10;
        x.height = 20;
}
```



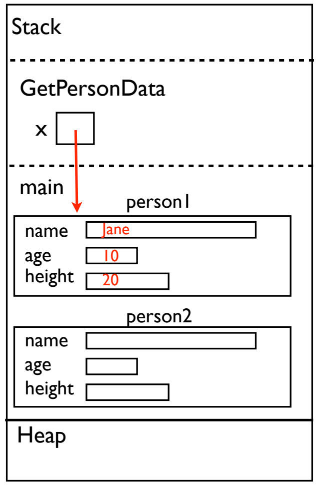
structures: passing structure

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
void GetPersonData(personT x);

main()
{
        personT person1;
        personT person2;

        GetPersonData(person1);
}

void GetPersonData (personT x){
        x.name = “Brian”;
        x.age = 10;
        x.height = 20;
}
```



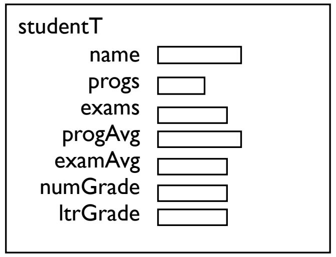
structures: passing address

```
typedef struct {
        char *name;
        int age;
        double height;
} personT;
void GetPersonData(personT *x);

main()
{
        personT person1;
        personT person2;

        GetPersonData(&person1);
}

void GetPersonData (personT *x){
        x->name = “Jane”;
        x->age = 10;
        x->height = 20;
}
```



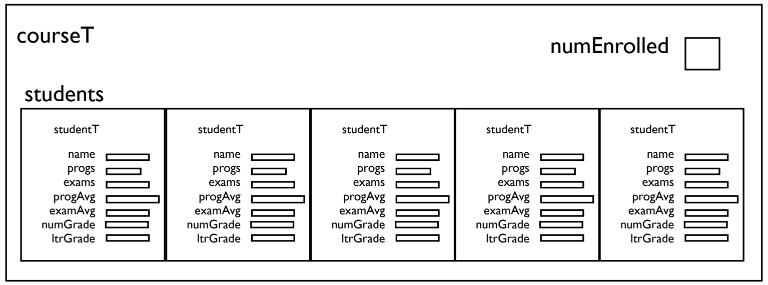
creating data structure with structure

```
#define   NUM_HW 6
#define   NUM_EXAMS 2

typedef struct {
    string name;
    int progs [NUM_HW];
    int exams [NUM_EXAMS];
    int progAvg;
    double examAvg;
    double numGrade;
    string ltrGrade;
} studentT;
```



creating data structure with structure

```
#define   MAX_ENROLL 5

typedef struct{
    studentT students[MAX_ENRILL];
    int numEnrolled;
} courseT;
```



creating data structure with structure

```
main()
{
       courseT cs106A;        /* allocates memory on stack */
       int i;

       cs106A.numEnrolled = 0;

       for (i=0; i<MAX_ENROLL; i++){
             cs106A.students[i] = GetStudentData();
             cs106A.numEnrolled++;
       }
}
```

creating data structure with structure

```
main()
{
       courseT *cs106A;
       int i;

       cs106A = (courseT *)malloc(sizeof(courseT));     /* allocates in heap */
       cs106A -> numEnrolled = 0;

       for (i=0; i<MAX_ENROLL; i++){
             cs106A -> students[i] = GetStudentData();
             cs106A -> numEnrolled++;
       }
}
```