CMSC201
Computer Science I for Majors

Lecture 13 – Lists (cont)

Last Class We Covered

- Modularity
  - Meaning
  - Benefits
- Program design
  - Top Down Design
  - Top Down Implementation
  - Bottom Up Implementation

#TBT

String Slicing

Any Questions from Last Time?

Today’s Objectives

- To review what we know about lists already

- To learn more about lists in Python
- To understand two-dimensional lists
  - (And more dimensions!)
- To practice passing lists to functions
- To learn about mutability and its uses

List Review

Vital List Algorithm: Iterating

- Write the code to iterate over and print out the contents of a list called **`classNames`**

```
index = 0
while index < len(classNames):
    print( classNames[index] )
    index += 1
```

Two-Dimensional Lists

Two-Dimensional Lists

- Lists can hold any type (int, string, float, etc.)
  - This means they can also hold another list
- We've looked at lists as being one-dimensional
  - But lists can also be two- (or three- or four- or five-, etc.) dimensional!

Two-Dimensional Lists: Syntax

- We use square brackets to indicate lists
  - 2D lists are essentially a list of lists
  - What do you think the syntax will look like?

```
twoD = [ ["first", "row"], ["second", 
"row"], ["last", "row"] ]
```

```
twoD = [ ["first",  "row"],
         ["second", "row"],
         ["last",   "row"]  ]
```

Same code, just lined up to be more readable

Two-Dimensional Lists: A Grid

- It may help to think of 2D lists as a grid

```
twoD = [ [1,2,3], [4,5,6], [7,8,9] ]
```

1	2	3
4	5	6
7	8	9

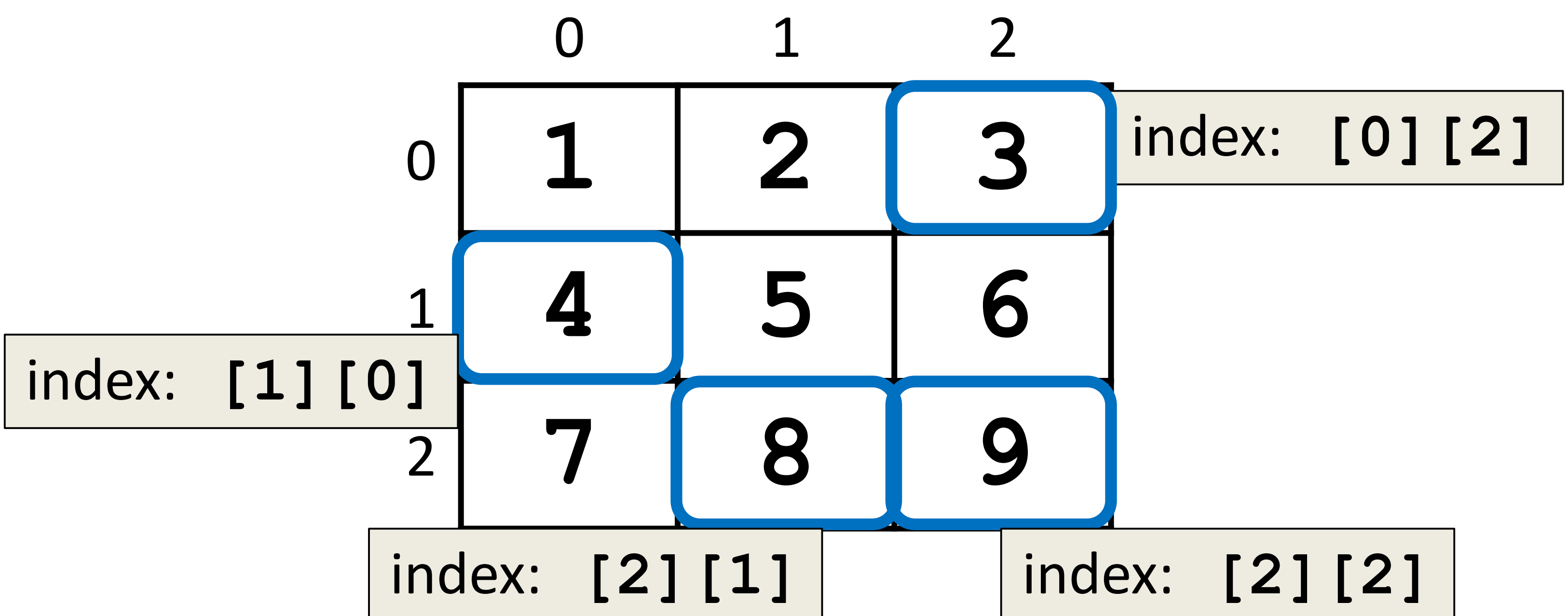
Two-Dimensional Lists: A Grid

- You access an element by the index of its row, and then the column
  - Remember – indexing starts at 0!

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

Two-Dimensional Lists: A Grid

- You access an element by the index of its row, and then the column
  - Remember – indexing starts at 0!



Lists of Strings

- Remember, a string is <u>like</u> a list of characters
- So what is a list of strings?
  - <u>Like</u> a two-dimensional list!

- We have the index of the string (the row)
- And the index of the character (the column)

Lists of Strings

- Lists in Python don't have to be rectangular
  - They can be jagged (rows of different lengths)

- Anything we could do with a one-dimensional list, we can do with a two-dimensional list
  - Slicing, index, appending

	0	1	2	3	4
0	A	l	i	c	e
1	B	o	b		
2	E	v	a	n	

names

Vital List Algorithm: 2D Creating

- Write the code to create a 2D list of symbols called **gameBoard**, given **width** and **height**

```
gameBoard = []
while len(gameBoard) < height:
    boardRow = []
    while len(boardRow) < width:
        boardRow.append(".")
    gameBoard.append(boardRow)
```


Vital List Algorithm: 2D Iterating

- Write the code to iterate over and print out the contents of a 2D list called **`gameBoard`**

```
row = 0
while row < len(gameBoard):
    col = 0
    while col < len( gameBoard[row] ):
        print( gameBoard[row][col], end = " ")
        col += 1
    print()  # print a newline at end of each row
    row += 1
```


Mutability

Mutable and Immutable

- In Python, certain structures cannot be altered once they are created and are called ***immutable***
  - These include integers, Booleans, and strings

- Other structures can be altered after they are created and are called ***mutable***
  - This includes lists

Mutability Example

- Do the variables change in the code below?

  `myList.append("dog")`

  – Yes, the list is updated in place to include “dog”

  `myString.upper()`

  – No, the string does not change to uppercase

  – Must use **`=`** to actually change **`myString`**

  - **`myString = myString.upper()`**

Lists and Mutability

- When you assign one list to another, it is by default a ***shallow copy*** of the list
- Any "in place" changes that are made to the shallow copy show up in the "original" list
  - Sort of like a nickname: one variable can be accessed with two separate names

- The other option is a ***deep copy*** of the list, but you must specify this is what you want

Shallow and Deep Copies

- A ***shallow copy*** is when the new variable only points to the old variable, rather than making an actual complete copy
- A ***deep copy*** is the opposite, creating a complete copy of the list for the new variable

- Both of these are useful in their own way
  - They serve different purposes
  - One is <u>not</u> “better” than the other

Shallow Copy Example

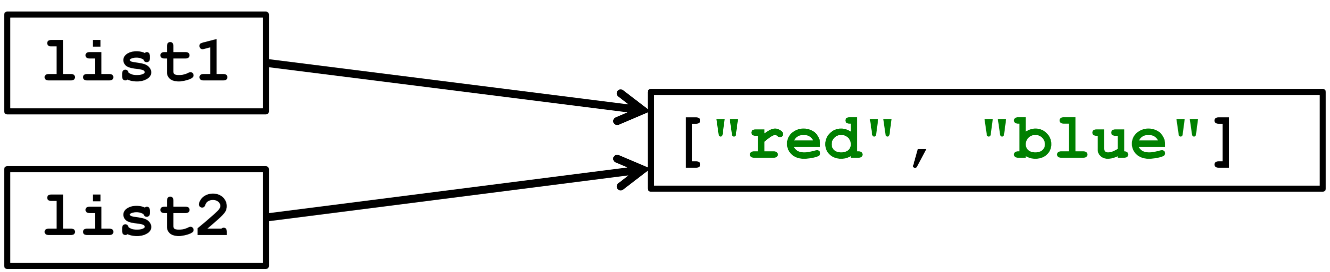
- A shallow copy and its effects on the original:

```
list1 = ["red", "blue"]
list2 = list1
list2.append("green")
list2[1] = "yellow"
print("original:      ", list1)
print("shallow copy: ", list2)
```

```
original:      ['red', 'yellow', 'green']
shallow copy:  ['red', 'yellow', 'green']
```


Shallow Copy

- When we make a shallow copy, we are essentially just giving the same list two different variable names
  - They both ***reference*** the same place in memory



Deep Copy

- There are two easy ways to do a deep copy:
  - Use slicing, and “slice” out the entire list

```
newList = originalList[ : ]
```

  - Cast the original as a list when assigning

```
newList = list(originalList)
```

- With these, Python ***returns*** a separate copy that it then assigns to the new variable
  - Now we have two separate, independent lists!

Deep Copy Example

```
list1 = ["red", "blue"]
list2 = list1[:]          # use slicing to copy
list2[1] = "yellow"
list3 = list(list1)       # use casting to copy
list3.append("purple")
print("original:      ", list1)
print("deep copy1:    ", list2)
print("deep copy2:    ", list3)
```

```
original:     ['red', 'blue']
deep copy1:   ['red', 'yellow']
deep copy2:   ['red', 'blue', 'purple']
```


Deep Copy

- Creates a copy of the entire list's contents, not just of the list itself
- Each variable now has its own individual list

```
list1 → ["red", "blue"]
list2 → ["red", "yellow"]
list3 → ["red", "blue", "purple"]
```

Mutability and Functions

Python Is “Lazy”

- Lists can be a lot bigger than Booleans, integers, or even strings!
- When we pass a list as an argument, Python doesn’t want to copy all of the values
  - Copying can take a lot of memory and time
- Instead of the values, when we pass a list, Python actually sends a ***reference*** to the list

Lists, Functions, and Mutability

- When arguments are passed to a function, their value is assigned to the formal parameters using the assignment operator

- With a list, we send a reference, not the value
- So does the function have a deep copy?
  - No, it has a *shallow* copy!
  - It's a ***reference*** to the original list

References

- A ***reference*** essentially states where the list is stored in the computer's memory
  - Mutable objects are always passed by reference
- Since lists are ***mutable***, that means that the function the list was passed to now has direct access to the "original" list
  - And can change its contents!!!

- **`main()`** has a list called **`myList`**

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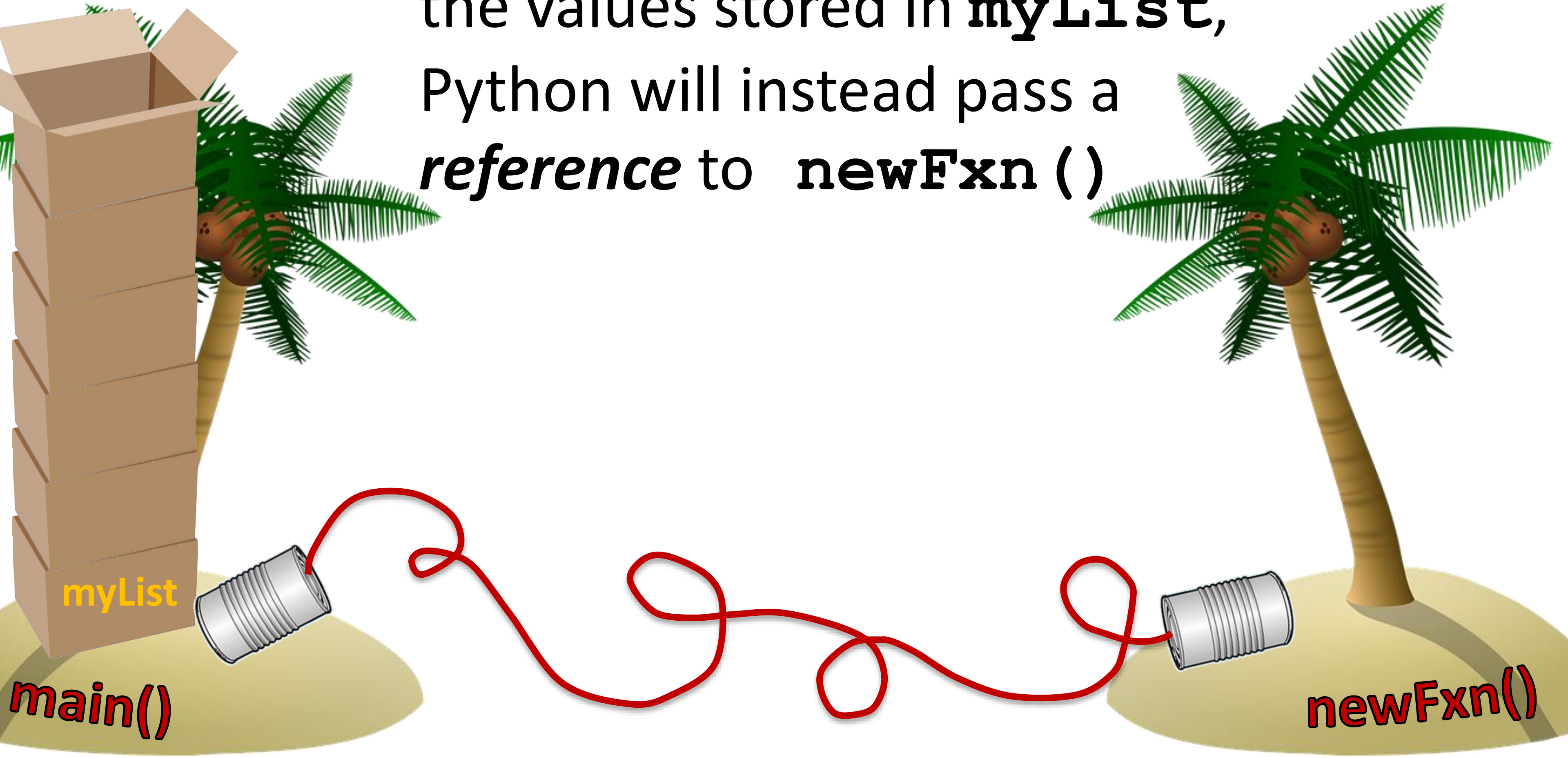
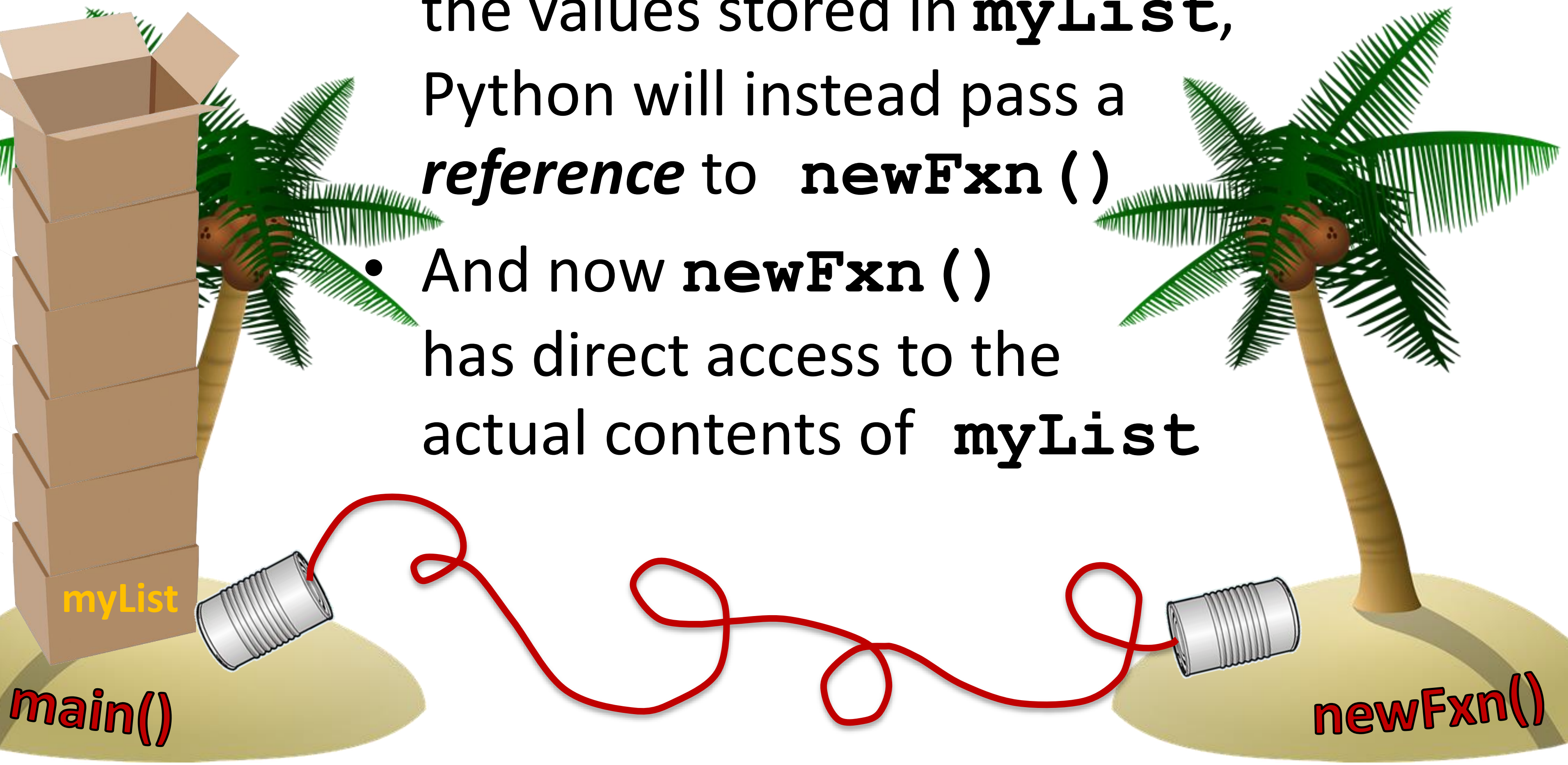
- Instead of copying over all of the values stored in **`myList`**, Python will instead pass a ***reference*** to **`newFxn()`**



- **`main()`** has a list called **`myList`**
- Instead of copying over all of the values stored in **`myList`**, Python will instead pass a ***reference*** to **`newFxn()`**
- And now **`newFxn()`** has direct access to the actual contents of **`myList`**



Mutability in Functions

- When a parameter is passed that is ***mutable***, it is now possible for the second function to directly access and change the contents
- This only works if we change the variable "in place" – assigning a new overall value to the variable will override the mutability
  - Any "in place" changes that are made to the shallow copy show up in the "original" list

Scope and Mutability in Functions

- A good general rule for if a change is “in place”:
- When you use something like **`.append()`** on the list, that’s an “in place” change
- When you use the ***assignment operator***, then that’s not an “in place” change
  - Unless you are editing one element: **`myList[2]`**

Scope and Mutability in Functions

Function is called, and formal parameter F is assigned the argument A

A is ***immutable*** (integer, string)

A **doesn't change** If F changes

A is ***mutable*** (lists)

F is assigned to something else
`F = [0, 1]`
`F = "hello"`

A **doesn't change** If F changes

F is modified in place
`F.append(2)`
`F[0] = 17`

A **changes** If F changes

Using Mutability

- Shallow copies are not a bad thing!

- Being able to
  - Pass a list to a function
  - Have that function make in place changes
  - And have those changes "stick"
- Can be very useful!

LIVECODING!!!

Cloning and Adopting Dogs

- Write a program that contains the following:

- A **`main()`** with a list of dogs at an adoption event
  - Use deep copy to "clone" the dogs by creating a second, unique list
- An **`adopt()`** function that takes in a list of dogs, and replaces all of their names with "adopted!"
  - These changes should "stick" in **`main()`** as well, <u>without</u> the function returning anything

Daily emacs Shortcut

- **`CTRL+L`**
  - Centers the screen on the cursor’s location

- Use the shortcut again to “move” the screen so the cursor’s at the top
  - Use it a third time to move it to the bottom
  - Once more will cycle it back to the center

Announcements

- Project 1 is out on Blackboard now
  - ***Design*** is due by Friday (Mar 29th) at 11:59:59 PM
    - Design is provided, but you must still think about it carefully to figure out how everything fits together!
  - ***Project*** is due by Friday (Apr 5th) at 11:59:59 PM
- Second midterm exam is April 15th and 16th

Image Sources

- Tesseract:
  - https://commons.wikimedia.org/wiki/File:Tesseract.gif
- Cardboard box:
  - https://pixabay.com/p-220256/
- Wooden ship (adapted from):
  - https://pixabay.com/p-307603/
- Coconut island (adapted from):
  - https://pixabay.com/p-1892861/