



A Crash Course on Scala

Amir H. Payberah
payberah@kth.se
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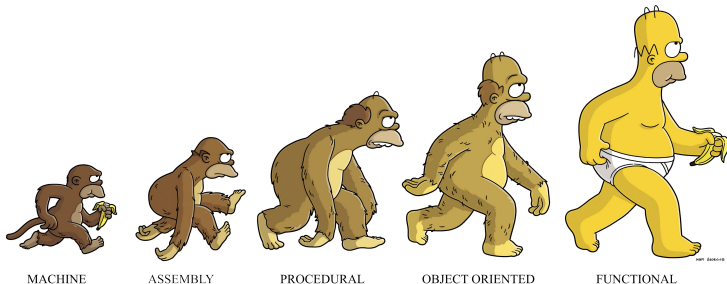
Introduction

- ▶ **Scala**: scalable language
- ▶ A blend of **object-oriented** and **functional programming**.
- ▶ Runs on the **Java Virtual Machine**.
- ▶ Designed by Martin Odersky at **EPFL**.



Functional Programming Languages

- ▶ Functions are **first-class** citizens:
 - Defined **anywhere** (including inside other functions).
 - Passed as **parameters** to functions and **returned as results**.
 - **Operators** to compose functions.



[<https://medium.com/@cscalfani/so-you-want-to-be-a-functional-programmer-part-1-1f15e387e536>]



HELLO
WORLD!



The “Hello, world!” Program

```
object HelloWorld {  
  def main(args: Array[String]) {  
    println("Hello, world!")  
  }  
}
```



Compile and Execute It!

```
// Compile it!  
> scalac HelloWorld.scala  
  
// Execute it!  
> scala HelloWorld
```

- ▶ It is always better to **separate sources and build products**.

```
// Compile it!  
> scalac -d classes HelloWorld.scala  
  
// Execute it!  
> scala -cp classes HelloWorld
```



Run It Interactively!

```
> scala
This is a Scala shell.
Type in expressions to have them evaluated.
Type :help for more information.

scala> object HelloWorld {
  |   def main(args: Array[String]) {
  |     println("Hello, world!")
  |   }
  | }
defined module HelloWorld

scala> HelloWorld.main(null)
Hello, world!

scala>:q
>
```



Run in Jupyter-Notebook

► Apache toree

The screenshot shows a Jupyter Notebook interface. At the top, it says "jupyter Hello World! Last Checkpoint: 8 minutes ago (autosaved)" and has a "Logout" button. Below this is a menu bar with "File", "Edit", "View", "Insert", "Cell", "Kernel", "Widgets", and "Help". To the right of the menu bar are "Trusted" and "Apache Toree - Scala" buttons. Below the menu bar is a toolbar with icons for file operations, navigation, and execution. The main area contains a code cell with the following Scala code:

```
In [1]: object HelloWorld {  
        def main(args: Array[String]) {  
            println("Hello, world!")  
        }  
    }  
  
    HelloWorld.main(null)
```

The output of the code cell is:

```
defined object HelloWorld  
Hello, world!
```

Below the code cell is an empty input field for the next cell, labeled "In []:".



Outline

- ▶ Scala basics
- ▶ FunctionsFunctions
- ▶ CollectionsCollections
- ▶ Classes and objectsClasses and objects
- ▶ SBTSBT



Scala Variables

- ▶ **Values:** immutable
- ▶ **Variables:** mutable
- ▶ Always use **immutable values** by default, unless you know for certain they need to be mutable.

```
var myVar: Int = 0
val myVal: Int = 1

// Scala figures out the type of variables based on the assigned values
var myVar = 0
val myVal = 1

// If the initial values are not assigned, it cannot figure out the type
var myVar: Int
val myVal: Int
```



Scala Data Types

- ▶ **Boolean**: true or false
- ▶ **Byte**: 8 bit signed value
- ▶ **Short**: 16 bit signed value
- ▶ **Char**: 16 bit unsigned Unicode character
- ▶ **Int**: 32 bit signed value
- ▶ **Long**: 64 bit signed value
- ▶ **Float**: 32 bit IEEE 754 single-precision float
- ▶ **Double**: 64 bit IEEE 754 double-precision float
- ▶ **String**: A sequence of characters

```
var myInt: Int
var myString: String
```



If ... Else

```
var x = 30;

if (x == 10) {
  println("Value of X is 10");
} else if (x == 20) {
  println("Value of X is 20");
} else {
  println("This is else statement");
}
```



Loops (1/3)

```
var a = 10

// do-while
do {
  println(s"Value of a: $a")
  a = a + 1
} while(a < 20)

// while loop execution
while(a < 20) {
  println(s"Value of a: $a")
  a = a + 1
}
```



Loops (2/3)

```
var a = 0
var b = 0

for (a <- 1 to 3; b <- 1 until 3) {
  println(s"Value of a: $a, b: $b")
}
```

```
/* output
Value of a: 1, b: 1
Value of a: 1, b: 2
Value of a: 2, b: 1
Value of a: 2, b: 2
Value of a: 3, b: 1
Value of a: 3, b: 2
*/
```



Loops (3/3)

```
// loop with collections  
val numList = List(1, 2, 3, 4, 5, 6)  
for (a <- numList) {  
  println(s"Value of a: $a")  
}
```

```
// for loop with multiple filters  
for (a <- numList if a != 3; if a < 5) {  
  println(s"Value of a: $a")  
}
```

```
// for loop with a yield  
// store return values from a for loop in a variable  
var retVal = for(a <- numList if a != 3; if a < 6) yield a  
println(retVal)
```



Exception Handling

```
import java.io.FileReader
import java.io.FileNotFoundException
import java.io.IOException

object Test {
  def main(args: Array[String]) {
    try {
      val f = new FileReader("input.txt")
    } catch {
      case ex: FileNotFoundException => println("Missing file exception")
      case ex: IOException           => println("IO Exception")
    } finally {
      println("Exiting finally...")
    }
  }
}
```




Outline

- ▶ Scala basics
- ▶ Functions
- ▶ Collections
- ▶ Classes and objects
- ▶ SBT



Functions - Definition

```
// def [function name]([list of parameters]): [return type] = [expr]
// the expression may be a {}-block
```

```
def addInt(a: Int, b: Int): Int = a + b

println("Returned Value: " + addInt(5, 7))
// Returned Value: 12
```

- ▶ You can also specify default values for all or some parameters.

```
def addInt(a: Int = 5, b: Int = 7): Int = a + b

// and then invoke with named parameters
println("Returned Value:" + addInt(a = 10))
// Returned Value: 17
```



Functions - Variable Arguments

```
def printStrings(args: String*) = {  
  var i : Int = 0;  
  for (arg <- args) {  
    println(s"Arg value[$i] = $arg")  
    i = i + 1;  
  }  
}  
  
printStrings("SICS", "Scala", "BigData")
```



Functions - Nested Functions

```
def factorial(i: Int): Int = {  
  def fact(i: Int, accumulator: Int): Int = {  
    if (i <= 1)  
      accumulator  
    else  
      fact(i - 1, i * accumulator)  
  }  
  
  fact(i, 1)  
}  
  
println(factorial(5))
```



Functions - Anonymous Functions

- ▶ Lightweight syntax for defining anonymous functions.

```
var inc = (x: Int) => x + 1
var x = inc(7) - 1
```

```
var mul = (x: Int, y: Int) => x * y
println(mul(3, 4))
```



Functions - Higher-Order Functions

```
def apply(f: Int => String, v: Int) = f(v)

def layout[A](x: A) = s"$x"

println(apply(layout, 10))
// [10]
```



Functions - Call-by-Value

- ▶ **Call-by-Value**: the value of the parameter is determined **before** it is passed to the function.

```
def time() = {  
  println("Getting time in nano seconds")  
  System.nanoTime  
}
```

```
def delayed(t: Long) {  
  println("In delayed method")  
  println(s"Param: $t")  
}
```

```
delayed(time())
```

```
/* output  
Getting time in nano seconds  
In delayed method  
Param: 2532847321861830  
*/
```



Functions - Call-by-Name

- ▶ **Call-by-Name:** the value of the parameter is not determined until it is called **within** the function.

```
def time() = {  
  println("Getting time in nano seconds")  
  System.nanoTime  
}
```

```
def delayed2(t: => Long) {  
  println("In delayed method")  
  println(s"Param: $t")  
}
```

```
delayed2(time())
```

```
/* output  
In delayed method  
Getting time in nano seconds  
Param: 2532875587194574  
*/
```




Functions - Partial Applied

- ▶ If you do not pass in arguments for all of the parameters.

```
def adder(m: Int, n: Int, p: Int) = m + n + p  
  
val add2 = adder(2, _: Int, _: Int)  
  
add2(3, 5)  
// 10
```



Outline

- ▶ Scala basics
- ▶ Functions
- ▶ Collections
- ▶ Classes and objects
- ▶ SBT



Collections

- ▶ Scala collections can be **mutable** and **immutable** collections.
- ▶ **Mutable** collections can be updated or extended **in place**.
- ▶ **Immutable** collections never change: additions, removals, or updates operators return a **new collection** and leave the old collection unchanged.



Collections

- ▶ Arrays
- ▶ Lists
- ▶ Sets
- ▶ Maps



Collections - Arrays

- ▶ A fixed-size sequential collection of elements of the same type
- ▶ Mutable

```
// Array definition  
val t: Array[String] = new Array[String](3)  
val t = new Array[String](3)
```

```
// Assign values or get access to individual elements  
t(0) = "zero"; t(1) = "one"; t(2) = "two"
```

```
// There is one more way of defining an array  
val t = Array("zero", "one", "two")
```



Collections - Lists

- ▶ A sequential collection of elements of the **same type**
- ▶ **Immutable**
- ▶ Lists represent a **linked list**

```
// List definition  
val l1 = List(1, 2, 3)  
val l1 = 1 :: 2 :: 3 :: Nil
```

```
// Adding an element to the head of a list  
val l2 = 0 :: l1
```

```
// Adding an element to the tail of a list  
val l3 = l1 :+ 4
```

```
// Concatenating lists  
val t3 = List(4, 5)  
val t4 = l1 ::: t3
```



Collections - Sets

- ▶ A sequential collection of elements of the **same type**
- ▶ **Immutable** and **mutable**
- ▶ No duplicates.

```
// Set definition  
val s = Set(1, 2, 3)
```

```
// Add a new element to the set  
val s2 = s + 0
```

```
// Remove an element from the set  
val s3 = s2 - 2
```

```
// Test the membership  
s.contains(2)
```



Collections - Maps

- ▶ A collection of key/value pairs
- ▶ Immutable and mutable

```
// Map definition  
var m1: Map[Char, Int] = Map()  
val m2 = Map(1 -> "Carbon", 2 -> "Hydrogen")
```

```
// Finding the element associated to a key in a map  
m2(1)
```

```
// Adding an association in a map  
val m3 = m2 + (3 -> "Oxygen")
```

```
// Returns an iterable containing each key (or values) in the map  
m2.keys  
m2.values
```




Common Other Types

- ▶ Tuples
- ▶ Option
- ▶ Either



Common Data Types - Tuples

- ▶ A fixed number of items of different types together
- ▶ Immutable

```
// Tuple definition
val t2 = (1 -> "hello") // special pair constructor
val t3 = (1, "hello", Console)
val t3 = new Tuple3(1, "hello", 20)

// Tuple getters
t3._1
t3._2
t3._3
```



Common Data Types - Option (1/2)

- ▶ Sometimes you **might** or **might not** have a **value**.
- ▶ **Java** typically returns the value **null** to indicate nothing found.
 - You may get a **NullPointerException**, if you don't check it.
- ▶ **Scala** has a null value in order to **communicate** with **Java**.
 - You should use it **only** for this purpose.
- ▶ Everyplace else, you should use **Option**.



Common Data Types - Option (2/2)

```
val numbers = Map(1 -> "one", 2 -> "two")  
// numbers: scala.collection.immutable.Map[Int, String] = Map((1, one), (2, two))
```

```
numbers.get(2)  
// res0: Option[String] = Some(two)
```

```
numbers.get(3)  
// res1: Option[String] = None
```

```
// Check if an Option value is defined (isDefined and isEmpty).  
val result = numbers.get(3).isDefined  
// result: Boolean = false
```

```
// Extract the value of an Option.  
val result = numbers.get(3).getOrElse("zero")  
// result: String = zero
```



Common Data Types - Either

- ▶ Sometimes you might **definitely have a value**, but it can be one of **two different types**.
- ▶ Scala provides the **Either** type for these cases.

```
def getNum(s: String): Either[Int, String] = try {  
  Left(s.toInt)  
} catch {  
  case _ => Right(s)  
}  
  
getNum("5")  
// Left(5)
```



Functional Combinators

- ▶ map
- ▶ foreach
- ▶ filter
- ▶ zip
- ▶ partition
- ▶ find
- ▶ drop and dropWhile
- ▶ foldRight and foldLeft
- ▶ flatten
- ▶ flatMap



Functional Combinators - `map`

- ▶ Evaluates a function over each element in the list, returning a list with the same number of elements.

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)
```

```
numbers.map((i: Int) => i * 2)
// res0: List[Int] = List(2, 4, 6, 8)
```

```
def timesTwo(i: Int): Int = i * 2
// timesTwo: (i: Int)Int
```

```
numbers.map(timesTwo _)
// or
numbers.map(timesTwo)
// res1: List[Int] = List(2, 4, 6, 8)
```



Functional Combinators - `foreach`

- ▶ It is like `map`, but returns nothing.

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)

val doubled = numbers.foreach((i: Int) => i * 2)
// doubled: Unit = ()

numbers.foreach(print)
// 1234
```




Functional Combinators - filter

- ▶ Removes any elements where the function you pass in evaluates to false.

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)

numbers.filter((i: Int) => i % 2 == 0)
// res0: List[Int] = List(2, 4)
```

```
def isEven(i: Int): Boolean = i % 2 == 0
// isEven: (i: Int)Boolean

numbers.filter(isEven)
// res2: List[Int] = List(2, 4)
```



Functional Combinators - zip

- ▶ Aggregates the contents of two lists into a single list of pairs.

```
val numbers = List(1, 2, 3, 4)
// numbers: List[Int] = List(1, 2, 3, 4)

val chars = List("a", "b", "c")
// chars: List[String] = List(a, b, c)

numbers.zip(chars)
// res0: List[(Int, String)] = List((1, a), (2, b), (3, c))
```



Functional Combinators - partition

- ▶ Splits a list based on where it falls with respect to a predicate function.

```
val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
// numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

numbers.partition(_ % 2 == 0)
// res0: (List[Int], List[Int]) = (List(2, 4, 6, 8, 10), List(1, 3, 5, 7, 9))
```



Functional Combinators - find

- ▶ Returns the first element of a collection that matches a predicate function.

```
val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
// numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

numbers.find(i => i > 5)
// res0: Option[Int] = Some(6)
```



Functional Combinators - `drop` and `dropWhile`

- ▶ `drop` drops the first `i` elements.
- ▶ `dropWhile` removes the first elements that match a predicate function.

```
val numbers = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
// numbers: List[Int] = List(1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

numbers.drop(5)
// res0: List[Int] = List(6, 7, 8, 9, 10)

numbers.dropWhile(_ % 3 != 0)
// res1: List[Int] = List(3, 4, 5, 6, 7, 8, 9, 10)
```



Functional Combinators - foldLeft

- ▶ Takes an **associative binary operator function** and uses it to collapse elements from the collection.
- ▶ It goes through the whole List, from **head (left)** to **tail (right)**.

```
val numbers = List(1, 2, 3, 4, 5)

numbers.foldLeft(0) { (acc, i) =>
  println("i: " + i + " acc: " + acc)
  i + acc
}
```

```
/* output
i: 1 acc: 0
i: 2 acc: 1
i: 3 acc: 3
i: 4 acc: 6
i: 5 acc: 10
15 */
```



Functional Combinators - `foldRight`

- ▶ It is the same as `foldLeft` except it runs in the **opposite direction**.

```
val numbers = List(1, 2, 3, 4, 5)

numbers.foldRight(0) { (i, acc) =>
  println("i: " + i + " acc: " + acc)
  i + acc
}
```

```
/* output
i: 5 acc: 0
i: 4 acc: 5
i: 3 acc: 9
i: 2 acc: 12
i: 1 acc: 14
15 */
```



Functional Combinators - `flatten`

- ▶ It collapses one level of nested structure.

```
List(List(1, 2), List(3, 4)).flatten  
// res0: List[Int] = List(1, 2, 3, 4)
```

```
List(Some(1), None, Some(3)).flatten  
// res0: List[Int] = List(1, 3)
```




Functional Combinators - flatMap

- ▶ It takes a function that works on the nested lists and then concatenates the results back together.

```
val nestedNumbers = List(List(1, 2), List(3, 4))  
// nestedNumbers: List[List[Int]] = List(List(1, 2), List(3, 4))  
  
nestedNumbers.flatMap(x => x.map(_ * 2))  
// res0: List[Int] = List(2, 4, 6, 8)
```



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Everything is an Object

- ▶ Scala is a pure **object-oriented** language.
- ▶ Everything is an **object**, including **numbers**.

```
1 + 2 * 3 / x  
(1).+(((2).*(3))./(x))
```

- ▶ **Functions** are also objects, so it is possible to pass functions as arguments, to store them in variables, and to return them from other functions.



Classes and Objects

```
// constructor parameters can be declared as fields and can have default values  
class Calculator(val brand = "HP") {  
  // an instance method  
  def add(m: Int, n: Int): Int = m + n  
}  
  
val calc = new Calculator  
calc.add(1, 2)  
println(calc.brand)  
// HP
```



Inheritance and Overloading Methods

- ▶ Scala allows the inheritance from just **one** class only.

```
class SciCalculator(_brand: String) extends Calculator(_brand) {  
  def log(m: Double, base: Double) = math.log(m) / math.log(base)  
}  
  
class MoreSciCalculator(_brand: String) extends SciCalculator(_brand) {  
  def log(m: Int): Double = log(m, math.exp(1))  
}
```



Singleton Objects

- ▶ A singleton is a class that can have only **one instance**.

```
class Point(val x: Int, val y: Int) {  
  def printPoint {  
    println(s"Point x location: $x");  
    println(s"Point y location: $y");  
  }  
}  
  
object SpecialPoint extends Point(10, 20)  
  
SpecialPoint.printPoint  
/* output  
Point x location: 10  
Point y location: 20  
*/
```



Abstract Classes

```
abstract class Shape {  
  // subclass should define this  
  def getArea(): Int  
}  
  
class Circle(r: Int) extends Shape {  
  override def getArea(): Int = { r * r * 3 }  
}  
  
val s = new Shape // error: class Shape is abstract  
val c = new Circle(2)  
c.getArea  
// 12
```



Traits

- ▶ A class can mix in any number of traits.

```
trait Car {  
  val brand: String  
}  
  
trait Shiny {  
  val shineRefraction: Int  
}  
  
class BMW extends Car with Shiny {  
  val brand = "BMW"  
  val shineRefraction = 12  
}
```




Generic Types

```
// a generic trait
trait Cache[K, V] {
  def get(key: K): V
  def put(key: K, value: V)
  def delete(key: K)
}

// a generic function
def remove[K](key: K)
```



Case Classes and Pattern Matching

- ▶ **Case classes** are used to store and match on the contents of a class.
- ▶ They are designed to be used with **pattern matching**.
- ▶ You can construct them **without using new**.

```
scala> case class Calculator(brand: String, model: String)
scala> val hp20b = Calculator("hp", "20B")

def calcType(calc: Calculator) = calc match {
  case Calculator("hp", "20B") => "financial"
  case Calculator("hp", "48G") => "scientific"
  case Calculator("hp", "30B") => "business"
  case _ => "Calculator of unknown type"
}

scala> calcType(hp20b)
```



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Simple Build Tool (SBT)

- ▶ An open source [build tool](#) for Scala and Java projects.
- ▶ Similar to Java's [Maven](#) or [Ant](#).
- ▶ It is written in [Scala](#).



SBT - Hello World!

```
$ mkdir hello  
$ cd hello  
$ cp <path>/HelloWorld.scala .  
$ sbt  
...  
> run
```



Running SBT

- ▶ **Interactive mode**

```
$ sbt  
> compile  
> run
```

- ▶ **Batch mode**

```
$ sbt clean run
```

- ▶ **Continuous build** and **test**: automatically recompile or run tests whenever you save a source file.

```
$ sbt  
> ~ compile
```



Common Commands

- ▶ `clean`: deletes all generated files (in target).
- ▶ `compile`: compiles the main sources (in `src/main/scala`).
- ▶ `test`: compiles and runs all tests.
- ▶ `console`: starts the Scala interpreter.
- ▶ `run <argument>*`: run the main class.
- ▶ `package`: creates a jar file containing the files in `src/main/resources` and the classes compiled from `src/main/scala`.
- ▶ `help <command>`: displays detailed help for the specified command.
- ▶ `reload`: reloads the build definition (`build.sbt`, `project/*.scala`, `project/*.sbt` files).



Create a Simple Project

- ▶ Create `project` directory.
- ▶ Create `src/main/scala` directory.
- ▶ Create `build.sbt` in the project root.



build.sbt

- ▶ A list of Scala expressions, separated by blank lines.
- ▶ Located in the project's [base directory](#).

```
$ cat build.sbt
name := "hello"

version := "1.0"

scalaVersion := "2.12.8"
```



Add Dependencies

▶ Add in `build.sbt`.

▶ Module ID format:

```
"groupId" %% "artifact" % "version" % "configuration"
```

```
libraryDependencies += "org.apache.spark" %% "spark-core" % "2.4.3"

// multiple dependencies
libraryDependencies += Seq(
  "org.apache.spark" %% "spark-core" % "2.4.3",
  "org.apache.spark" % "spark-streaming_2.12" % "2.4.3",
  "org.apache.spark" % "spark-streaming-kafka-0-10_2.12" % "2.4.3"
)
```



Cluster Development Environments



LogicalClocks Hopworks

► <https://www.hops.site>

The screenshot shows the Hopworks web interface. The top navigation bar includes the Hopworks logo, a search bar, and a user profile icon. The left sidebar lists various features: Jupyter, Jobs, Kafka, Model Serving, Experiments, Data Sets, Settings, Python, Members, and Metadata Designer. The main content area displays configuration options for a Jupyter environment, including a 'Start' button and tabs for Experiment, Parallel Experiments, Distributed Training, Spark (Static), and Spark (Dynamic). The configuration options are:

- Hours to shutdown: 6
- Driver memory (MB): 2048
- Driver virtual cores: 1
- Number of executors: 1
- Executor memory (MB): 4096
- Executor virtual cores: 1

Under the 'Advanced' section, there are additional options:

- Base Directory: /Jupyter/
- + Archive: No additional archives
- + Jar: No additional jars
- + Python: No additional python dependencies
- + File: No additional files

At the bottom left of the sidebar, there is a 'Cluster Utilization: 1%' indicator and GPU resource information: 'Allocated GPUs: 0', 'Available GPUs: 21', and 'Overused GPU Requests: 0'.



Databricks

► <https://community.cloud.databricks.com>

The screenshot shows the Databricks community dashboard. On the left is a vertical navigation sidebar with icons for Home, Workspace, Recents, Data, Clusters, Jobs, and Search. The main content area features a 'Welcome to databricks' header with the Databricks logo. Below the header are three primary action cards: 'Explore the Quickstart Tutorial' (with a document icon and a lightbulb), 'Import & Explore Data' (with a dashed box icon and a cloud upload icon), and 'Create a Blank Notebook' (with a document icon and a plus sign). Each card includes a brief description of the action. At the top right of the main area is an 'Upgrade' button. Below the action cards are three sections: 'Common Tasks' with links for 'New Notebook', 'Create Table', 'New Cluster', 'New Job', 'Import Library', and 'Read Documentation'; 'Recents' showing a recent document 'lec3'; and 'What's new in v3.1' with a bulleted list of updates: 'Instance Pools' and 'Databricks Runtime 6.0 will drop Python 2 support', followed by a link to 'View latest release notes'.

Summary



Summary

- ▶ Scala basics
- ▶ Functions
- ▶ Collections
- ▶ Classes and objects
- ▶ SBT



Summary - Your Turn

- ▶ The most **important/interesting** thing you learned today?
- ▶ <https://tinyurl.com/yxl8oyxf>





References

- ▶ M. Odersky, Scala by example, 2011.

Questions?