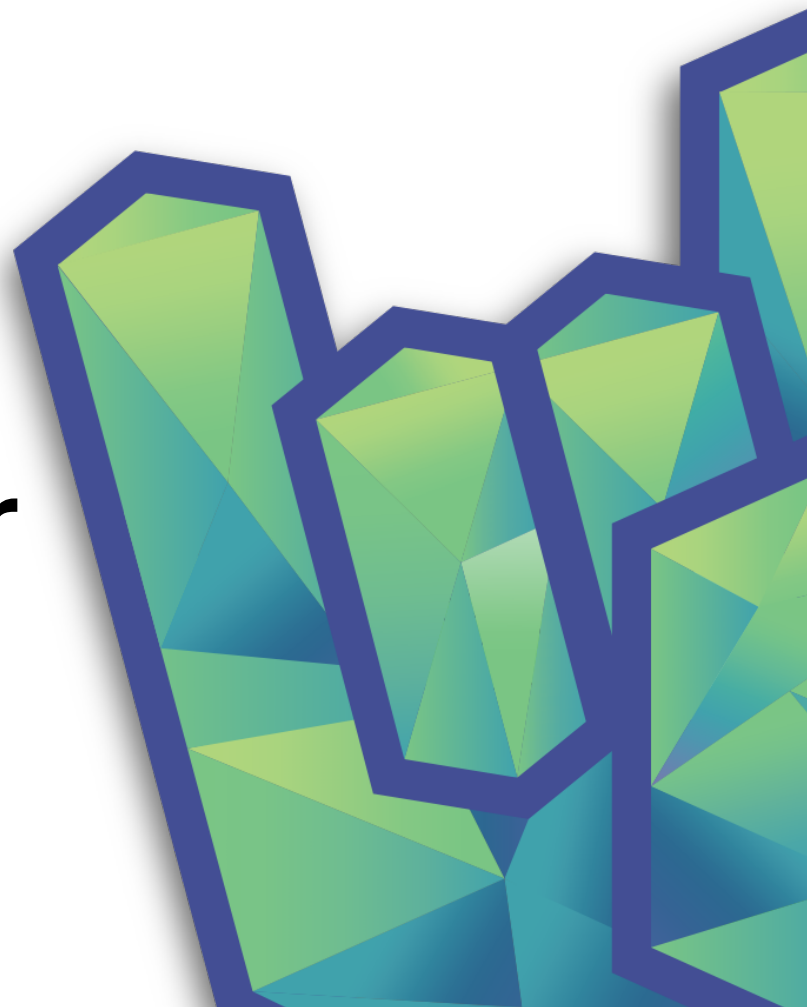
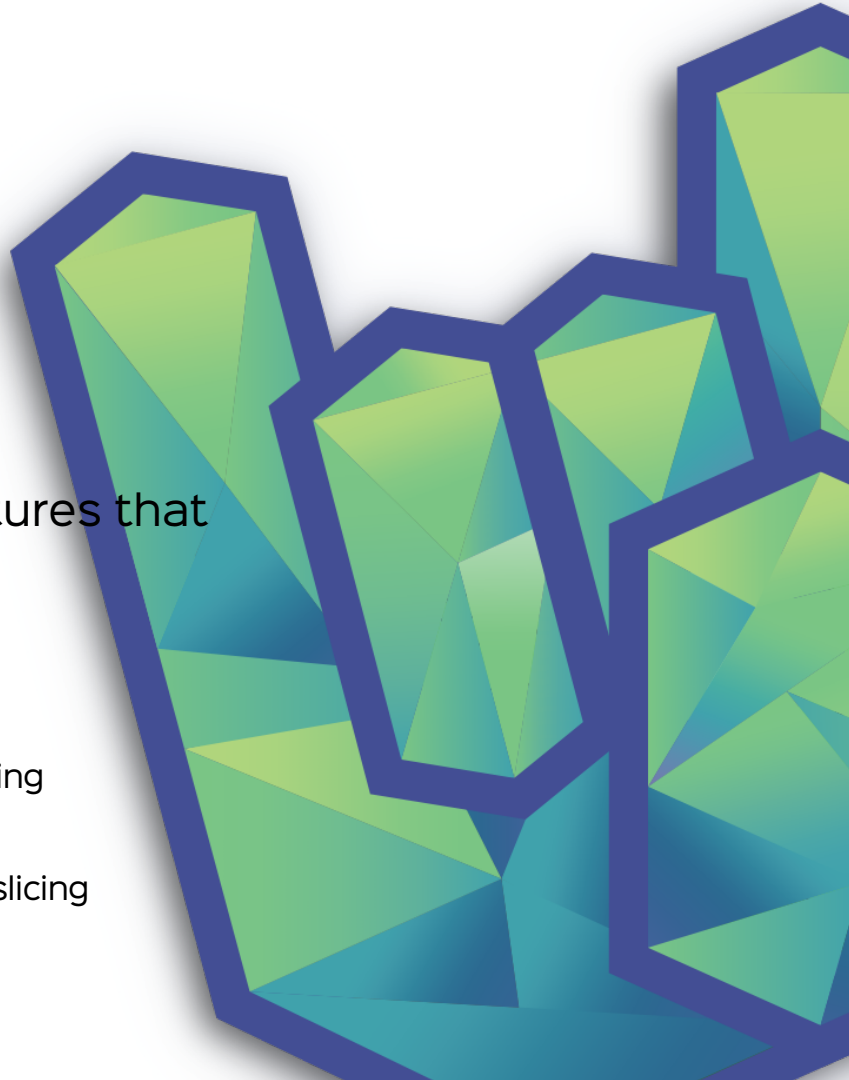
Sequences:
List, Array, Vector



Sequences

```
trait Seq[+A] {
  def head: A
  def tail: Seq[A]
}
```



A (*very*) general interface for data structures that

- have a *well defined order*
- can be *indexed*

Supports various operations:

- *apply, iterator, length, reverse* for indexing and iterating
- concatenation, appending, prepending
- *a lot* of others: grouping, sorting, zipping, searching, slicing

List

```
sealed abstract class List[+A]
case object Nil extends List[Nothing]
case class ::[A](val hd: A, val tl: List[A]) extends List[A]
```

A LinearSeq *immutable* linked list

- *head, tail, isEmpty* methods are fast: O(1)
- most operations are O(n): *length, reverse*

Sealed - has two subtypes:

- object Nil (empty)
- class ::

Lists in Action

Vararg *apply* factory method for building instances

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

Some of the most used operations: accessors and transforms

```
numbers.head                          // 1
numbers.tail                          // List(2,3)
numbers map (_ + 1)                   // List(2,3,4)
```

Handy for comprehensions

```
for (x <- numbers if x > 2)
  yield (x, x * x)                    // List((3,9))
```

Lists in Action (2)

Lists reuse references to tails

sugar for
`::.apply(42, simple)`

```
// structural re-use
val simple = List(54)
val prepended = 42 :: simple

prepended.tail == simple            // true
```

A lot of useful functions are supported out of the box

```
// other utilities
List.fill(3)("apples")              // List("apples","apples","apples")
numbers foreach println             // prints all elements to console
numbers mkString "; "               // 1; 2; 3
numbers.reverse                     // List(3,2,1)
```

Array

```
final class Array[T]
    extends java.io.Serializable
    with java.lang.Cloneable
```

The equivalent of simple Java arrays

- can be manually constructed with predefined lengths
- can be *mutated* (updated in place)
- are interoperable with Java's T[] arrays
- indexing is fast

Where's the Seq?!*

Arrays in Action

Instantiating "manually", with an exact length

```
val allocatedArray = new Array[String](3)   // filled with nulls
```

Instantiating via the *apply* vararg factory method

```
val numbers = Array(1,2,3,4)
```

Multi-dimensional arrays = arrays of arrays

```
val multiDimArray = Array.ofDim(2,3)        // a 2 x 3 array
```

Accessing elements: use *apply*

```
numbers(3) // 4
```

Arrays in Action (2)

Modifying an element in-place: use *update*

```
// syntax sugar - rewritten as numbers.update(1, 9)
numbers(1) = 9
```

Standard functions, uniform with the other Seqs

```
numbers :+ 5          // Array(1,9,3,4,5)
numbers.reverse       // Array(4,3,9,1) via a LOT of magic
```

Automatic conversion to Seq

```
// implicit* conversion to Seq[Int]
val numbersSeq: Seq[Int] = numbers
// utilities
numbersSeq.sum              // 17
numbersSeq.toList           // List(1,9,3,4)
```

also available in all collections:

toArray, toMap, toSet, toSeq, toStream*

Vector

```
final class Vector[+A]
```

The default implementation for *immutable sequences*

- *effectively constant* indexed read and write: $O(\log_{32}(n))$
- fast element addition: append/prepend
- implemented as a fixed-branched trie (branch factor 32)
- good performance for large sizes

```
val noElements = Vector.empty
val numbers = noElements :+ 1 :+ 2 :+ 3     // Vector(1,2,3)
val modified = numbers updated (0, 7)       // Vector(7,2,3)
```

Vectors in Action

A small List vs Vector performance comparison

- measure time for *updated* calls
- *updated* modifies an element and returns a new collection

Testing for:

- a large number of elements (1 million)
- a significant number of random writes (1000)

```
val maxCapacity = 1000000
val maxRuns = 1000
```

Vectors in Action (2)

(slide unused)

(tested in the code – for test snippet, see old slides)

```
val numbersList = (1 to maxCapacity).toList
val numbersVector = (1 to maxCapacity).toVector

getWriteTime(numbersList)                    // 7145903.006
getWriteTime(numbersVector)                  // 4339.59
```

List

- searches for position, step by step
- replaces element
- keeps the tail in new instance

Vector

- searches for position in tree
- replaces the whole 32-element chunk
- keeps all other chunks in new instance

Scala rocks