# Introduction to XQuery

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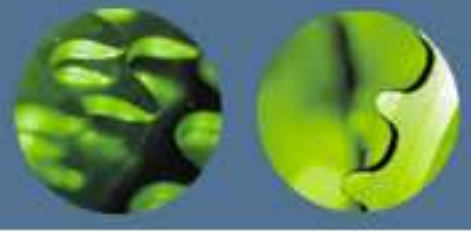
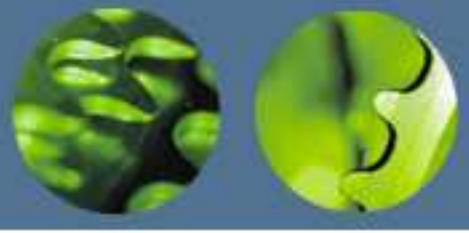


# About this course...

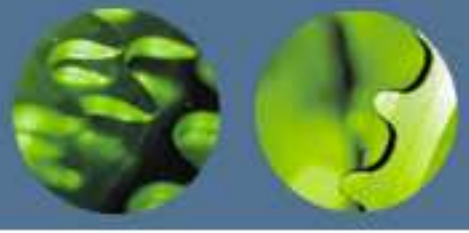
- These slides are for a one-day tutorial offered by Priscilla Walmsley at various industry conferences.
- If you are interested in having Priscilla present this tutorial, or a longer XQuery course, to your group, please contact her at pwalmsley@datypic.com.
- The slides were last updated on June 21, 2006 and are up to date with the June 2006 CR draft of XQuery.



# Schedule

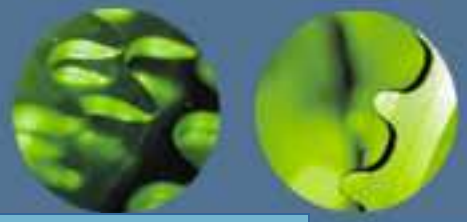
- Morning Session
  - XQuery in Context
  - The Data Model
  - XQuery Syntax and Expressions
- Afternoon Session
  - Advanced Queries (Sorting, Joining)
  - Functions and Modules
  - Types
  - Schemas


XQuery in Context



# What is XQuery?

- A query language that allows you to:
  - select elements/attributes from input documents
  - join data from multiple input documents
  - make modifications to the data
  - calculate new data
  - add new elements/attributes to the results
  - sort your results



# XQuery Example

input document

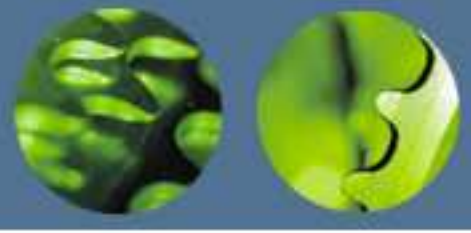
```
<order num="00299432" date="2004-09-15" cust="0221A">
  <item dept="WMN" num="557" quantity="1" color="tan"/>
  <item dept="ACC" num="563" quantity="1"/>
  <item dept="ACC" num="443" quantity="2"/>
  <item dept="MEN" num="784" quantity="1" color="blue"/>
  <item dept="MEN" num="784" quantity="1" color="red"/>
  <item dept="WMN" num="557" quantity="1" color="sage"/>
</order>
```

query

```
for $d in distinct-values(doc("ord.xml")//item/@dept)
let $items := doc("ord.xml")//item[@dept = $d]
order by $d
return <department name="{$d}"
                totalQuantity="{sum($items/@quantity)}"/>
```

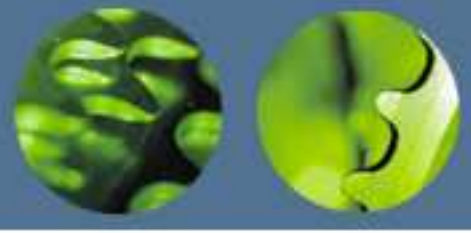
results

```
<department name="ACC" totalQuantity="3"/>
<department name="MEN" totalQuantity="2"/>
<department name="WMN" totalQuantity="2"/>
```



# Uses for XQuery

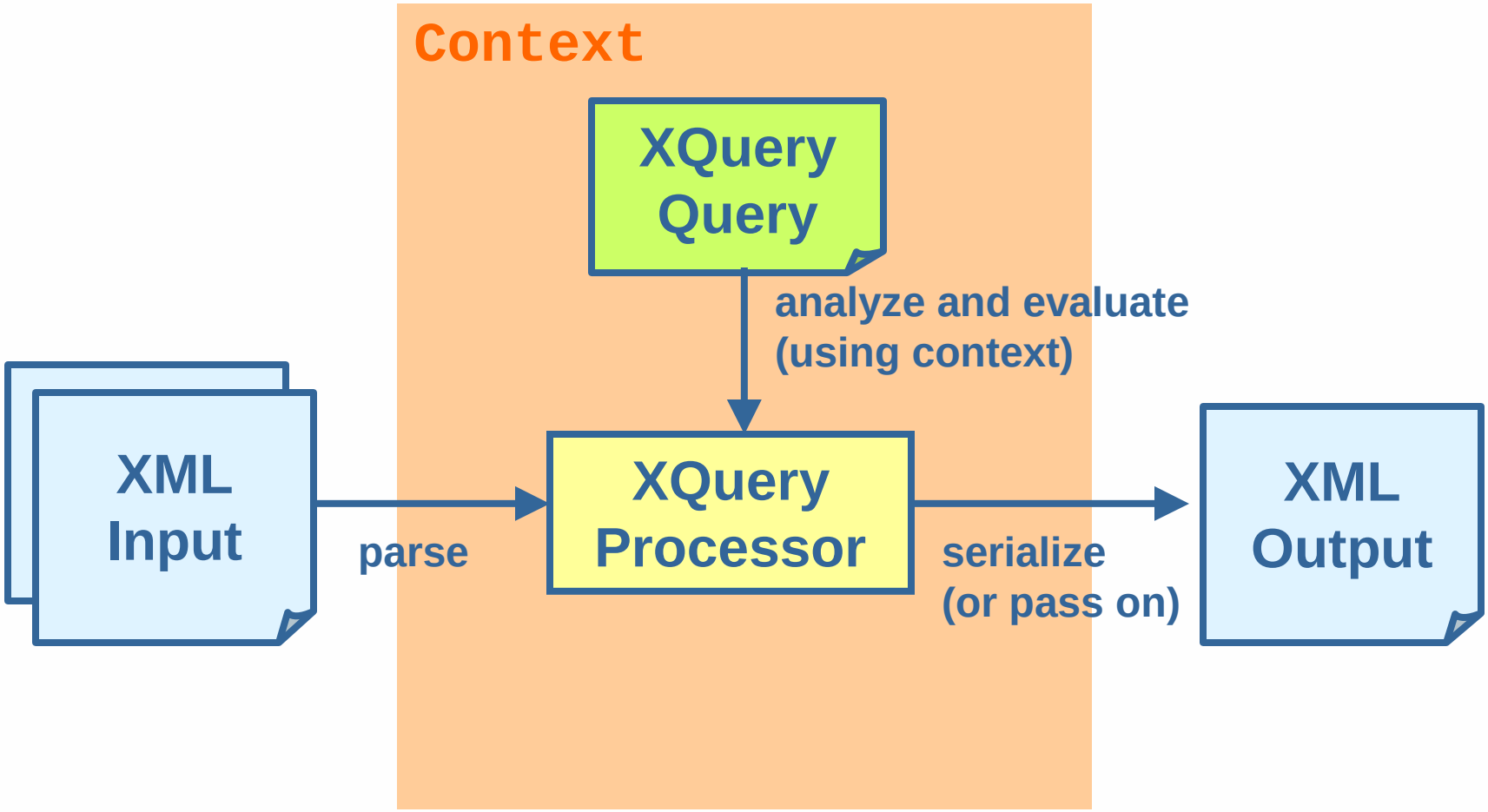
- As varied as the uses for XML. Examples:
  - Extracting information from a database for use in a Web service
  - Generating summary reports on data stored in an XML database
  - Searching textual documents on the Web for relevant information and compiling the results
  - Selecting and transforming XML data to XHTML to be published on the Web
  - Pulling data from databases to be used for application integration
  - Splitting up an XML document that represents multiple transactions into multiple XML documents

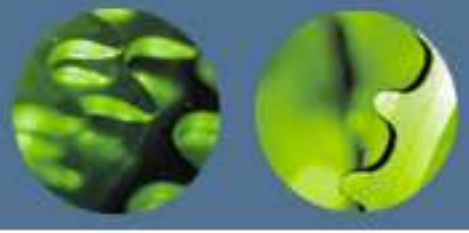


# XQuery Design Goals

- A language that is:
  - useful for both structured and unstructured data
  - protocol independent, allowing a query to be evaluated on any system with predictable results
  - a declarative language rather than a procedural one
  - strongly typed
    - allows for optimization and better error detection
  - able to accept collections of multiple documents
  - compatible with other W3C standards
    - XML 1.1, Namespaces, XML Schema, XPath

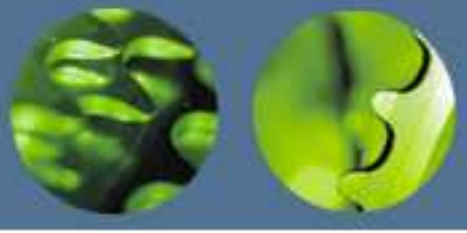
# The XQuery Processing Model (Simplified)





# XML Input

- Could be:
  - text files that are XML documents
  - fragments of XML documents that are retrieved from the web using a URI
  - a collection of XML documents that are associated with a particular URI
  - data stored in native XML databases
  - data stored in relational databases that have an XML front-end
  - in-memory XML documents

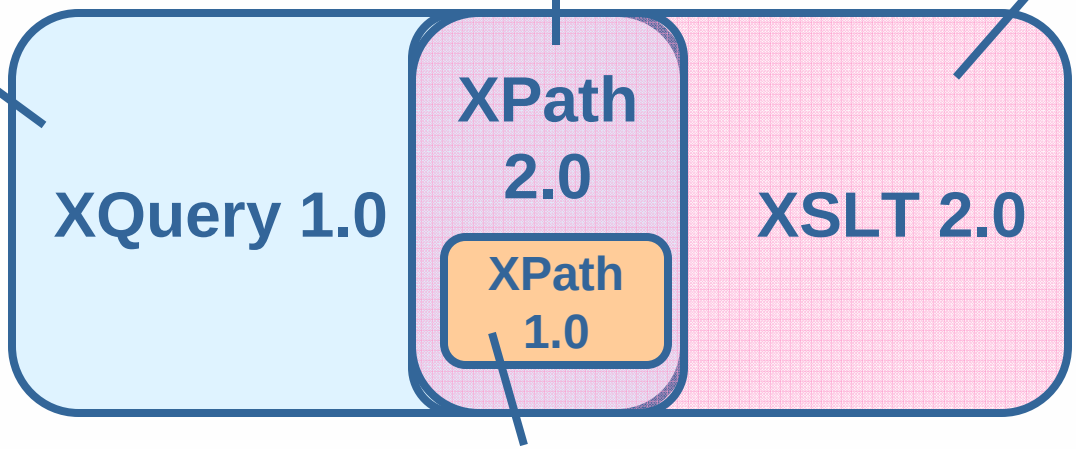


# XQuery, XSLT and XPath

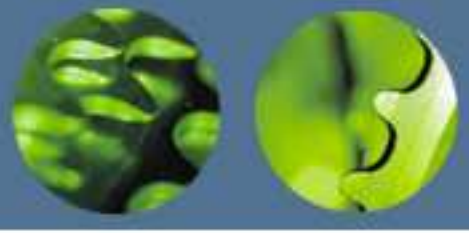
FLWOR Expressions
XML Constructors
Query Prolog
User-Defined Functions

Conditional Expressions
Arithmetic Expressions
Quantified Expressions
Built-In Functions & Operators
Data Model

Stylesheets
Templates
etc.



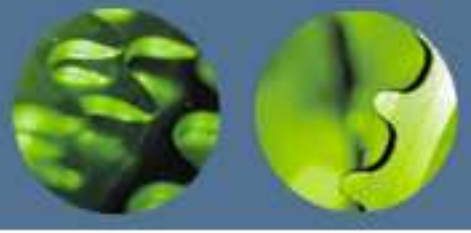

Path Expressions
Comparison Expressions
Some Built-In Functions



# Current Status

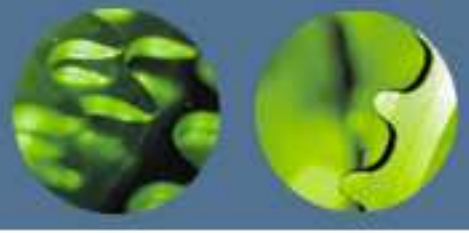
- Work in progress by the W3C XML Query Working Group
  - `http://www.w3.org/XML/Query`
- Current phase is Candidate Recommendation
- Will probably be finished in late 2006 (??)

# The Example Documents



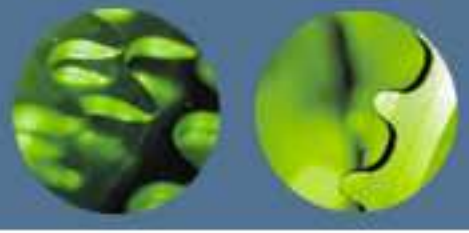
# Product Catalog (cat.xml)

```
<catalog>
  <product dept="WMN">
    <number>557</number>
    <name language="en">Linen Shirt</name>
    <colorChoices>beige sage</colorChoices>
  </product>
  <product dept="ACC">
    <number>563</number>
    <name language="en">Ten-Gallon Hat</name>
  </product>
  <product dept="ACC">
    <number>443</number>
    <name language="en">Golf Umbrella</name>
  </product>
  <product dept="MEN">
    <number>784</number>
    <name language="en">Rugby Shirt</name>
    <colorChoices>blue/white blue/red</colorChoices>
    <desc>Our <i>best-selling</i> shirt!</desc>
  </product>
</catalog>
```



# Prices (prc.xml)

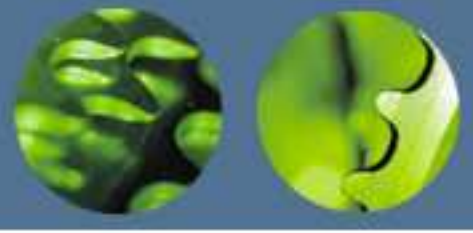
```
<prices>
  <priceList effDate="2004-11-15">
    <prod num="557">
      <price currency="USD">29.99</price>
      <discount type="CLR">10.00</discount>
    </prod>
    <prod num="563">
      <price currency="USD">69.99</price>
    </prod>
    <prod num="443">
      <price currency="USD">39.99</price>
      <discount type="CLR">3.99</discount>
    </prod>
  </priceList>
</prices>
```



# Order (ord.xml)

```
<order num="00299432" date="2004-09-15" cust="0221A">
  <item dept="WMN" num="557" quantity="1" color="beige"/>
  <item dept="ACC" num="563" quantity="1"/>
  <item dept="ACC" num="443" quantity="2"/>
  <item dept="MEN" num="784" quantity="1" color="blue/white"/>
  <item dept="MEN" num="784" quantity="1" color="blue/red"/>
  <item dept="WMN" num="557" quantity="1" color="sage"/>
</order>
```


Easing into XQuery



# Selecting Nodes from the Input Document

- Open the product catalog

```
doc("cat.xml")
```

calls a *function* named doc to open the `catalog.xml` file

- Retrieve all the product names

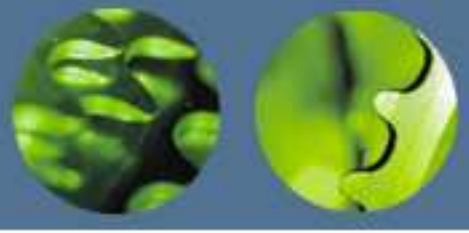
```
doc("cat.xml")/catalog/
    product/name
```

navigates through the elements in the document using a *path expression*

- Select only the product names from department ACC

```
doc("cat.xml")/catalog/
    product[@dept='ACC']/name
```

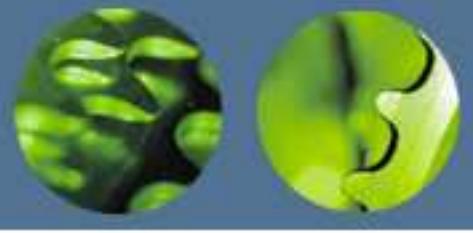
uses a *predicate* to limit the products



# The Results

```
doc("cat.xml")/catalog/product[@dept='ACC']/name
```

```
<name language="en">Ten-Gallon Hat</name>
<name language="en">Golf Umbrella</name>
```



# Path Expressions and FLWOR Expressions

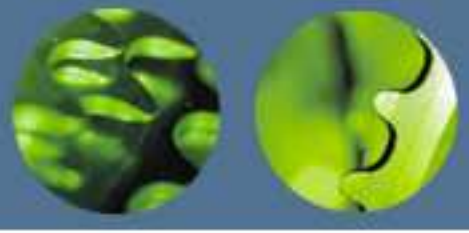
```
doc("cat.xml")/catalog/product[@dept='ACC']/name
```

path expression

- Another way of saying the same thing:

```
for $product in doc("cat.xml")/catalog/product
where $product/@dept='ACC'
return $product/name
```

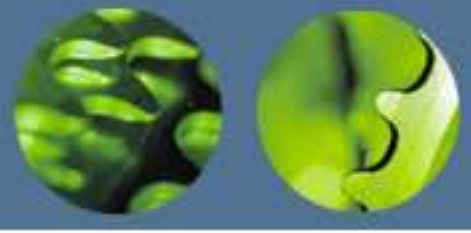
FLWOR expression



# Sort the Results

```
for $product in
  doc("cat.xml")/catalog/product
where $product/@dept='ACC'
order by $product/name
return $product/name
```

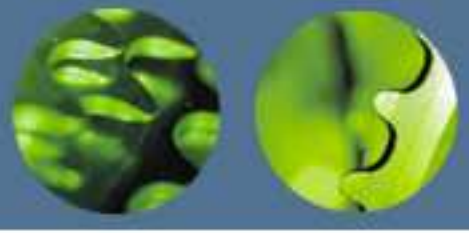
```
<name language="en">Golf Umbrella</name>
<name language="en">Ten-Gallon Hat</name>
```



# Wrap the Results in a ul Element

```
<ul type="square">{
  for $product in
    doc("cat.xml")/catalog/product
  where $product/@dept='ACC'
  order by $product/name
  return $product/name
}</ul>
```

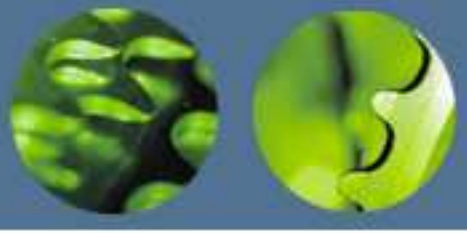
```
<ul type="square">
  <name language="en">Golf Umbrella</name>
  <name language="en">Ten-Gallon Hat</name>
</ul>
```



# Wrap Each Name in an li Element

```
<ul type="square">{
  for $product in
    doc("cat.xml")/catalog/product
  where $product/@dept='ACC'
  order by $product/name
  return <li>{$product/name}</li>
}</ul>
```

```
<ul type="square">
 <li><name language="en">Golf Umbrella</name></li>
 <li><name language="en">Ten-Gallon Hat</name></li>
</ul>
```

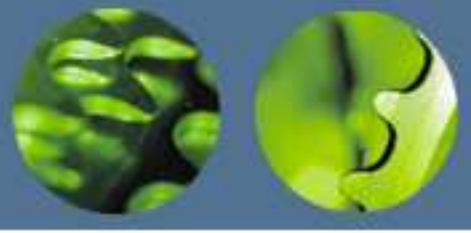


# Eliminate the name Elements

```
<ul type="square">{
  for $product in
    doc("cat.xml")/catalog/product
  where $product/@dept='ACC'
  order by $product/name
  return <li>{data($product/name)}</li>
}</ul>
```

```
<ul type="square">
  <li>Golf Umbrella</li>
  <li>Ten-Gallon Hat</li>
</ul>
```

# The Data Model



# Nodes, Atomic Values and Items

- Nodes
  - elements, attributes and other XML components

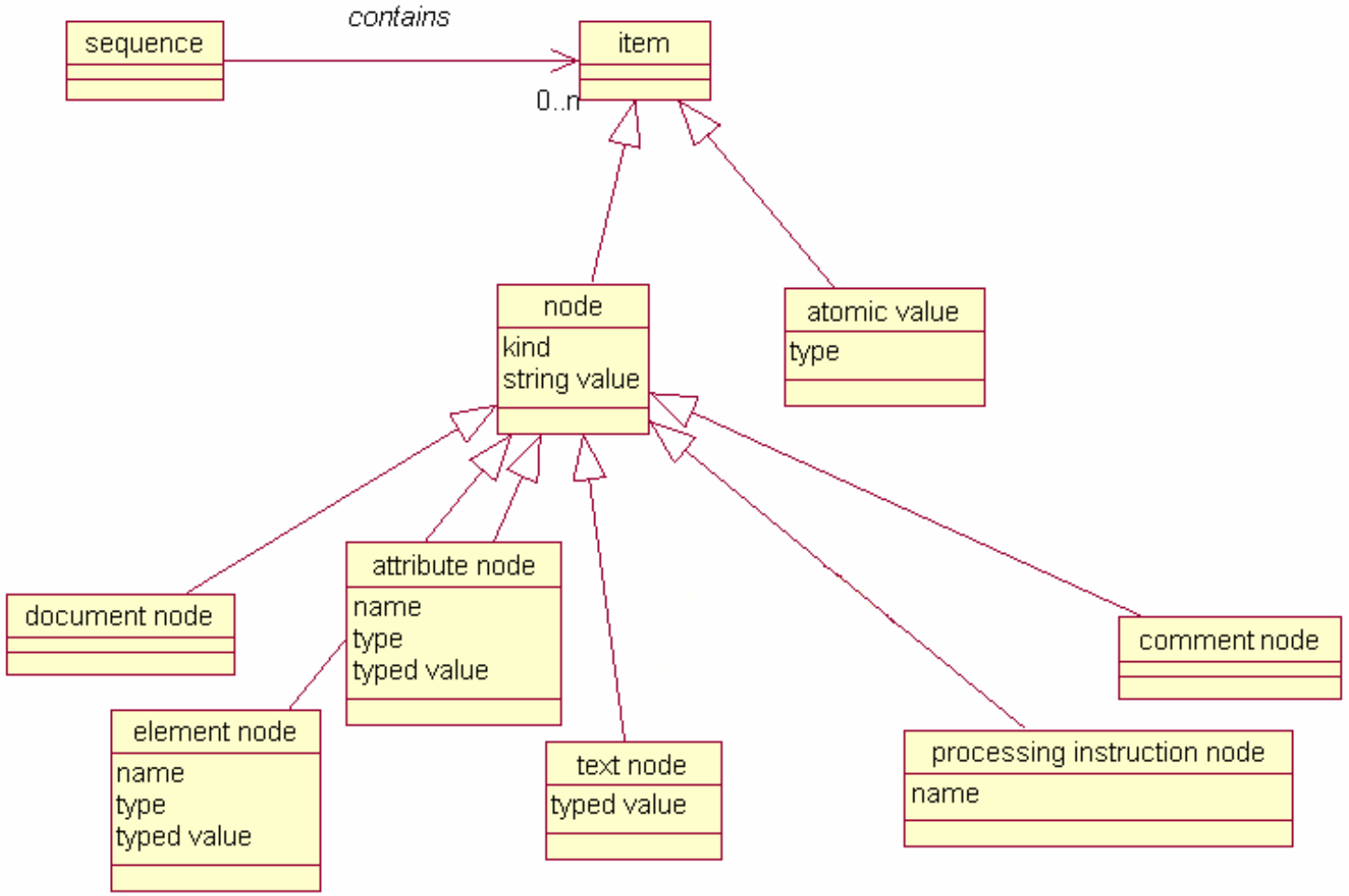
```
<number>557</number>
dept="MEN"
```

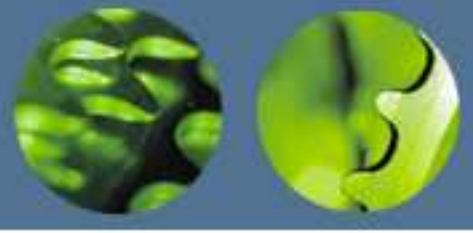
- Atomic values
  - individual data values, not an "element" or "attribute"

```
557
"MEN"
```

- Items
  - Atomic values *or* nodes

# Components of the Data Model

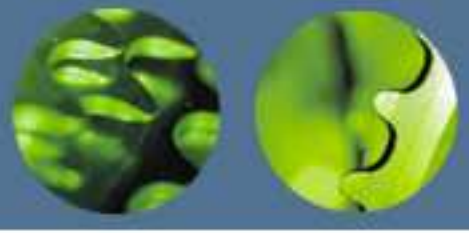




# An XML Hierarchy of Nodes

- document node
  - element node (catalog)
    - element node (product)
      - attribute node (dept)
      - element node (number)
        - text node (784)
      - element node (name)
        - attribute node (language)
        - text node ("Rugby Shirt")
      - element node (colorChoices)
        - text node ("blue/white blue/red")
      - element node (desc)
        - text node ("Our ")
        - element node (i)
          - text node ("best-selling")
        - text node (" shirt!")

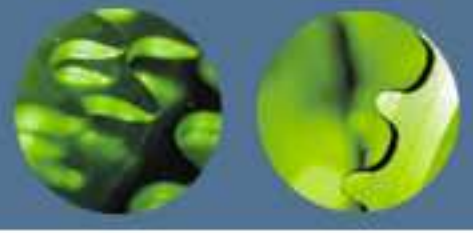
```
<catalog>
  <product dept="MEN">
    <number>784</number>
    <name language="en">Rugby Shirt</name>
    <colorChoices>blue/white blue/red</colorChoices>
    <desc>Our <i>best-selling</i> shirt!</desc>
  </product>
</catalog>
```



# Nodes

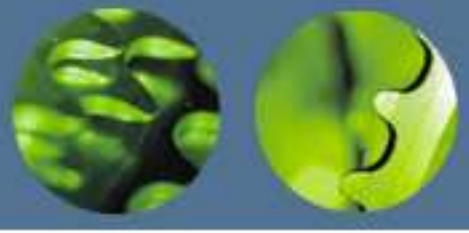
- Nodes:
  - have a "kind"
    - element, attribute, text, document, processing instruction, comment
  - may have a name
    - **`number`**, **`dept`**
  - have a string value
    - "**`557`**", "**`MEN`**"
  - may have a typed value
    - integer **`557`**, string **`MEN`**
  - have a unique identity

```
<number>557</number>
dept="MEN"
```



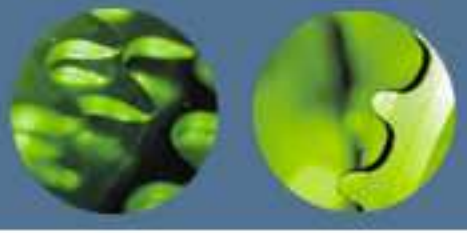
# Family Relationships of Nodes

- Children
  - Element nodes can have zero, one or more children
    - Attributes are not considered children of an element node
- Parent
  - Each element and attribute node has one parent
    - Even though attributes are not children of elements, elements are parents of attributes!
- Ancestors
  - A node's parent, parent's parent, etc. all the way back to the document node
- Descendants
  - A node's children, children's children, etc.
- Siblings
  - Other nodes that have the same parent



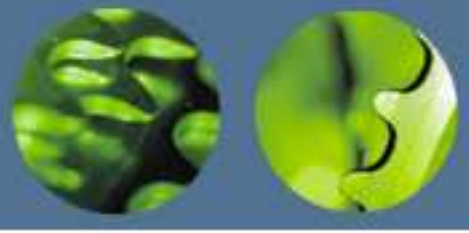
# Atomic Values

- Individual data values
  - no association with any particular node
- Every atomic value has a type
  - based on the XML Schema atomic types
    - e.g. **`xs:string`**, **`xs:integer`**
  - can also be the generic type **`xs:untypedAtomic`**
    - when not validated with a schema



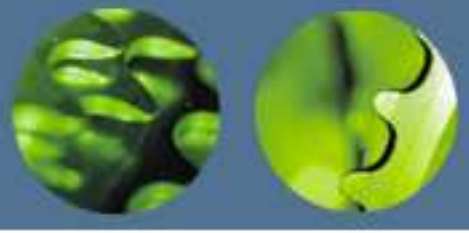
# How Atomic Values Are Created

- using a literal value
  - **`"Catalog"`**, **`12`**
- the result of a function
  - **`count(//number)`**
- explicitly extracting the value of a node
  - **`data(<number>557</number>)`**
- automatically extracting the value of a node
  - process is called *atomization*
  - **`substring(<number>557</number>,1, 2)`**



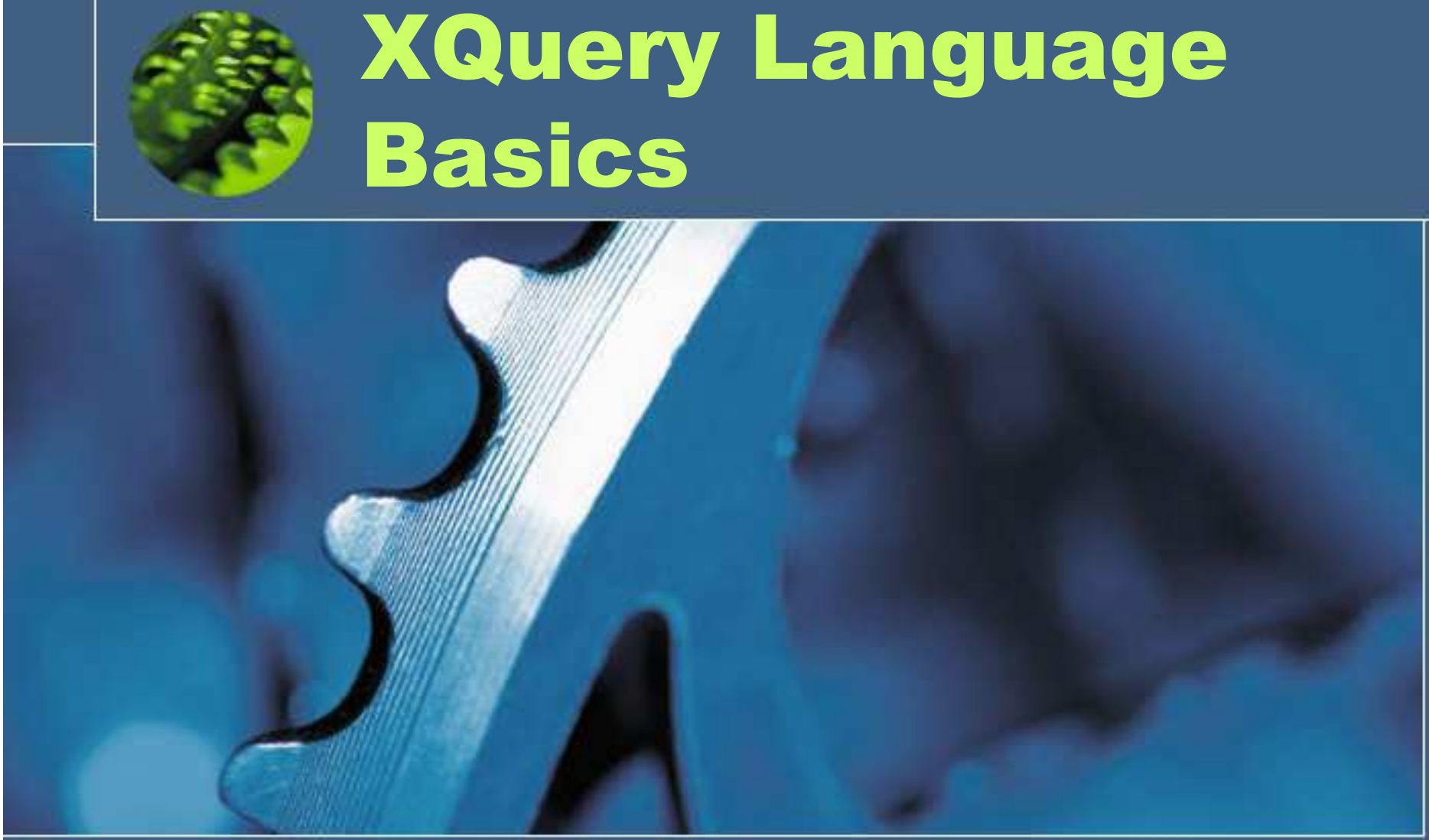
# Sequences

- Ordered lists of zero, one or more items
- A sequence of one item is exactly the same as the item itself
- A sequence of zero items is known as "the empty sequence"
  - different from zero, a zero-length string ("")
- There are no sequences within sequences

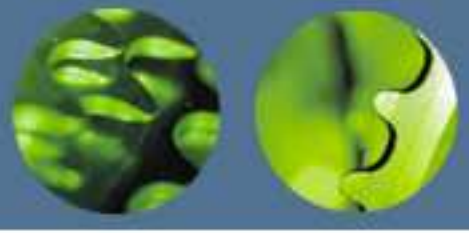


# How Sequences Are Created

- Result of an expression that returns nodes
  - **`catalog//product`**
    - returns a sequence of **`product`** element nodes
  - **`catalog//foo`**
    - returns the empty sequence
- Constructed manually
  - **`(1, 2, 3)`**
    - returns a sequence of 3 atomic values (integer)
  - **`(1 to 6)`**
    - returns a sequence of 6 atomic values (integer)
  - **`()`**
    - returns the empty sequence



# XQuery Language Basics



# Expressions: Basic Building Blocks

FLWOR Expression

Path Expression

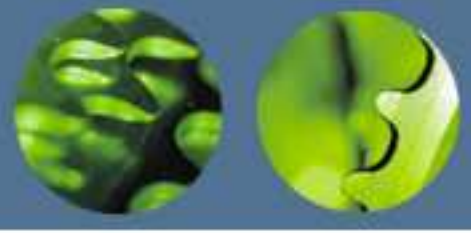
```
for $d in distinct-values(doc("ord.xml")//item/@dept)
let $items := doc("ord.xml")//item[@dept = $d]
order by $d
return <department name="{$d}"
           totalQuantity="{sum($items/@quantity)}"/>
```

Element Constructor

Function Call

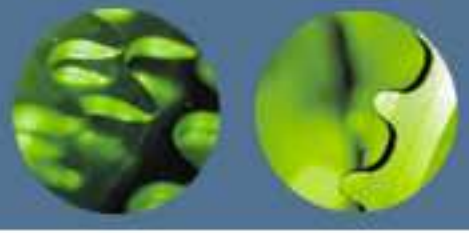
Variable Reference

Comparison Expression



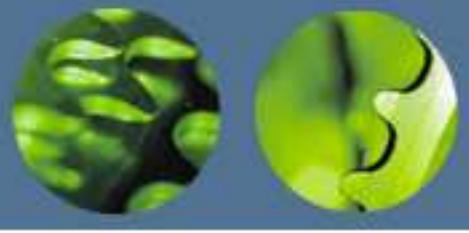
# The XQuery Syntax

- A declarative language of nested expressions
- Compact, non-XML syntax
- Case-sensitive
- Whitespace
  - tabs, space, carriage return, line feed
  - allowed (ignored) between language tokens
  - considered significant in quoted strings and constructed elements
- No special end-of-line character



# Keywords and Names

- Keywords and operators
  - case-sensitive, generally lower case
  - may have several meanings depending on context
    - e.g. "`*`" or "`in`"
  - no reserved words
- All names must be valid XML names
  - for variables, functions, elements, attributes
  - can be associated with a namespace



# Evaluation Order

- Every kind of expression has an evaluation order
  - e.g. **and** takes precedence over **or**

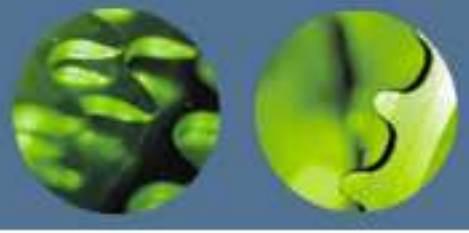
```
true() and true() or false() and false()
```

**returns true**

- Parentheses can be used around any expression to affect evaluation order

```
true() and (true() or false()) and false()
```

**returns false**



# Literal Values and Constants

- Literal values can be expressed as:
  - strings (in single or double quotes)

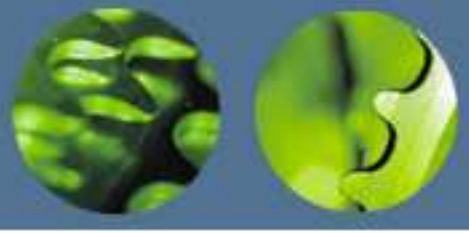
```
doc("cat.xml")//product/@dept = "WMN"
```

  - numbers

```
doc("ord.xml")//item/@quantity > 1
```

  - values constructed to be of a specific type

```
doc("prc.xml")//@effDate >
   xs:date("2004-10-11")
```

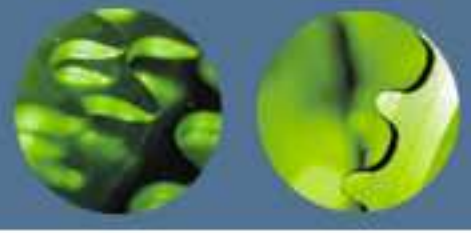


# Variables

- Identified by a name preceded by a $
- Variables are defined in several places
  - FLWOR expressions
  - Query prologs
  - Outside the query by the processor
  - Function signatures

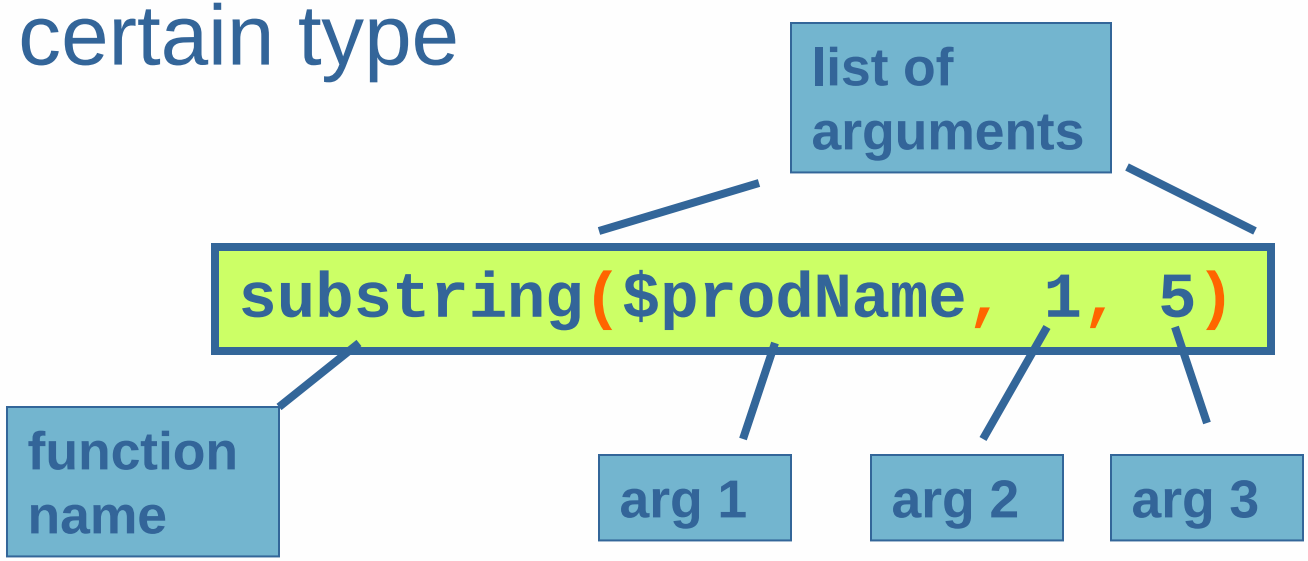
```
for $prod in
  (doc("cat.xml")//product)
return $prod/number
```

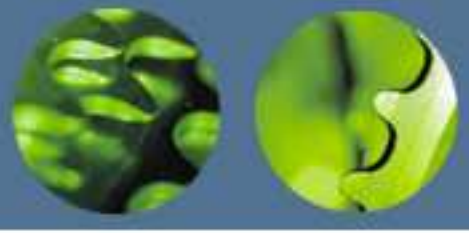
```
declare function local:getProdNum
   ($prod as element()) as element()
   { $prod/number };
```



# Function Calls

- An argument can be any single expression
  - e.g. a variable reference, a path expression
- An argument may be required to have a certain type





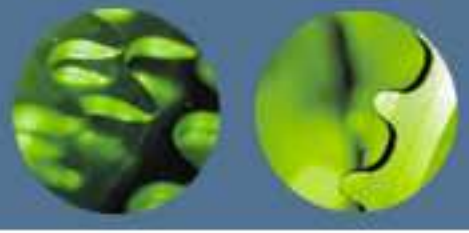
# Comments

- XQuery comments
  - Delimited by `(:` and `:)`
  - Anywhere insignificant whitespace is allowed
  - Do not appear in the results

```
(: This query... :)
```

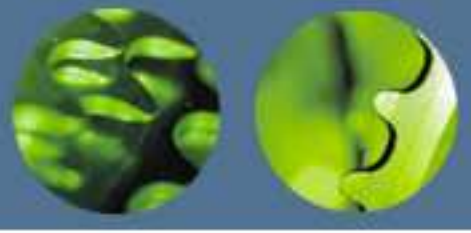
- XML comments
  - May appear in the results
  - XML-like syntax

```
<!-- This element... -->
```



# Comparisons

- Two kinds:
  - *value* comparisons
    - **`eq, ne, lt, le, gt, ge`**
    - used to compare individual values
    - each operand must be a single atomic value or a node containing a single atomic value
  - *general* comparisons
    - **`=, !=, <, <=, >, >=`**
    - can be used with sequences of multiple items



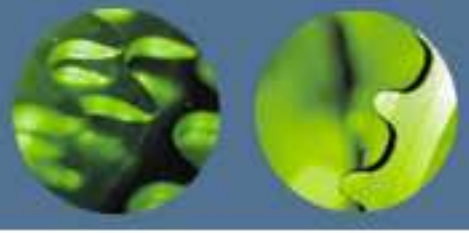
# Value vs. General Comparisons

```
doc("ord.xml")//item/@quantity > 1
```

- returns true if any **`quantity`** attributes have values greater than 1

```
doc("ord.xml")//item/@quantity gt 1
```

- returns true if there is only *one* **`quantity`** attribute returned by the expression, and its value is greater than 1
- if more than one **`quantity`** is returned, an error is raised

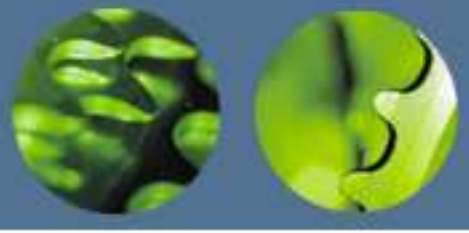


# Conditional Expressions

- if-then-else syntax

```
for $prod in (doc("cat.xml")/catalog/product)
return if ($prod/@dept = 'ACC')
       then <acc>{data($prod/number)}</acc>
       else <other>{data($prod/number)}</other>
```

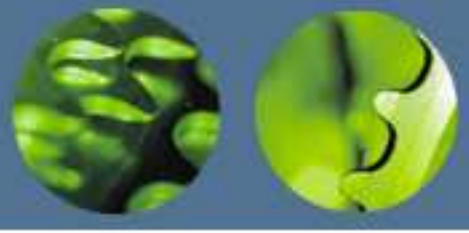
- parentheses around **`if`** expression are required
- else is always required
  - but it can be just **`else ()`**



# Effective Boolean Value

- "**`if`**" expression must be boolean
  - if it is not, its *effective boolean value* is found
- effective boolean value is false for:
  - the **`xs:boolean`** value **`false`**
  - the number **`0`** or **`NaN`**
  - a zero-length string
  - the empty sequence
- it's an error for a sequence of many atomic values
- otherwise it is true (e.g. a list of elements)

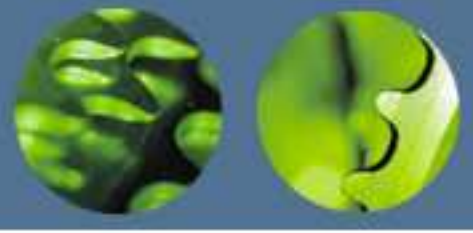
```
if (doc("ord.xml")//item)
then "Item List: " else ""
```



# Nesting Conditional Expressions

- Conditional expressions can be nested
  - provides "else if" functionality

```
if ($prod/@dept = 'ACC')
then <accessory>{data($prod/number)}</accessory>
else if ($prod/@dept = 'WMN')
     then <womens>{data($prod/number)}</womens>
     else if ($prod/@dept = 'MEN')
          then <mens>{data($prod/number)}</mens>
          else <other>{data($prod/number)}</other>
```



# Logical Expressions

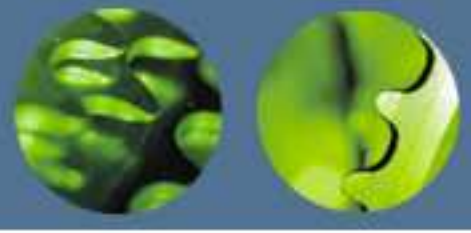
- **and** and **or** operators
  - **and** has precedence over **or**
  - use parentheses to change precedence

```
if ($isDiscounted and
($discount > 10 or $discount < 0))
then 10 else $discount
```

- Use **not** function to negate

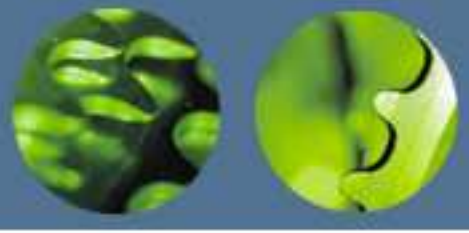
```
if (not($isDiscounted)) then 0 else $discount
```

- As with conditional expressions, effective boolean value is evaluated



# The Query Prolog

- Declarations of various settings, such as:
  - namespace declarations
  - function declarations
  - imports of external modules and schemas
  - default collation
- Appears before the body of the query
  - each declaration separated by a semicolon



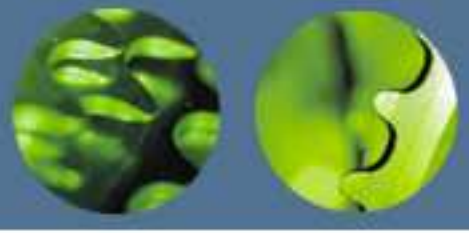
# Query Prolog

```
xquery version "1.0";
declare boundary-space preserve;
declare namespace ord = "http://datypic.com/ord";
declare function local:getProdNums
  ($catalog as element()) as xs:integer*
  {for $prod in $catalog/product
   return xs:integer($prod/number)};

<title>Order Report</title>,
(for $item in doc("ord.xml")//item
 order by $item/@num
 return $item)
```

prolog

query body


Path Expressions



# Path Expressions

- Used to traverse an input document, selecting elements and attributes of interest

```
doc("ord.xml")/order/item/@dept
```

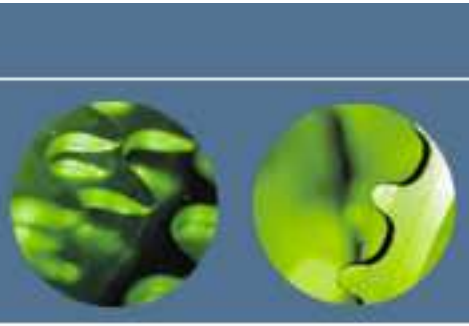
```
doc("ord.xml")/order/item[@dept = 'ACC']
```

```
item
```

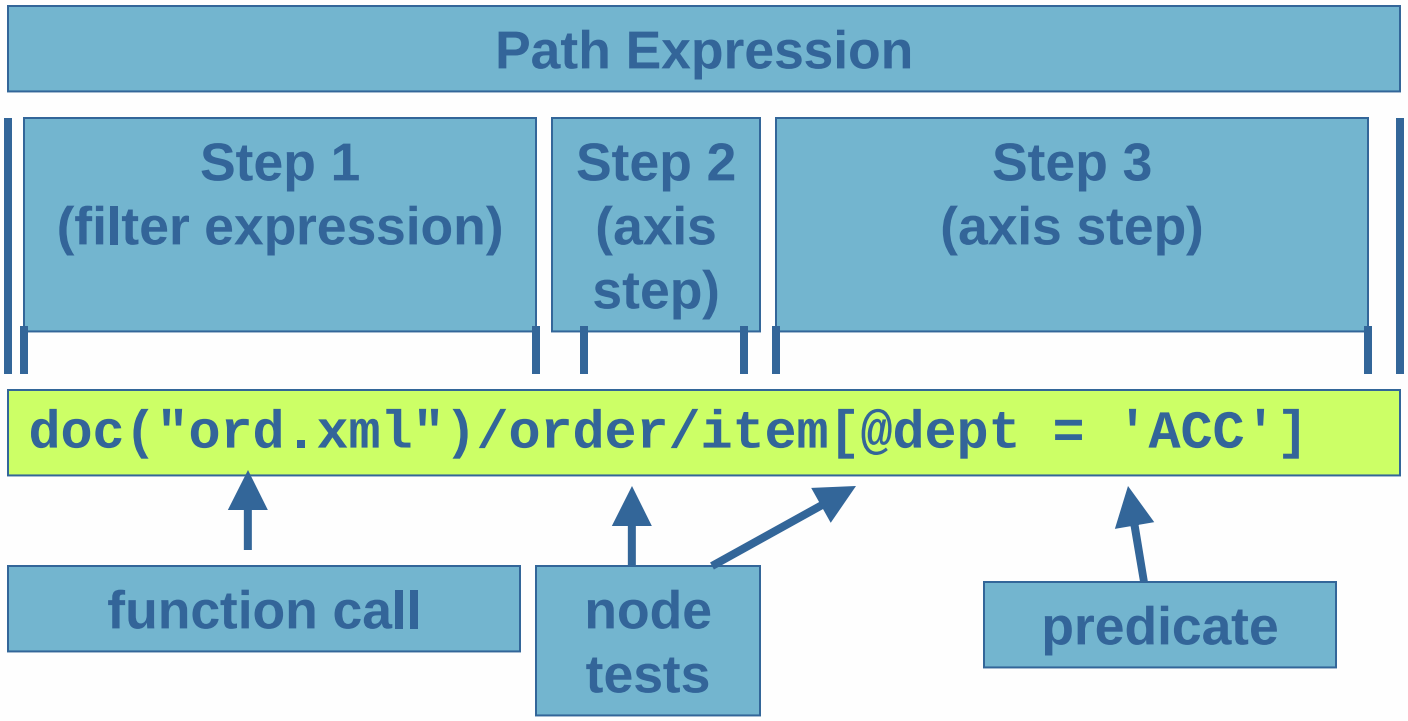
```
item[3]
```

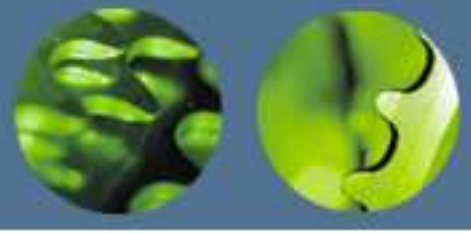
```
//order/item
```

```
doc("ord.xml")//item
```



# Structure of a Path Expression





# Paths and Context

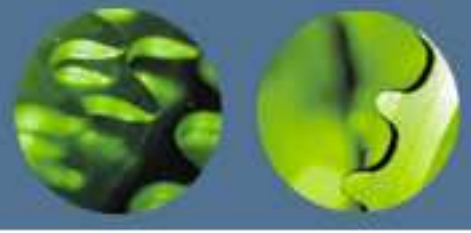
- Path expressions are always evaluated in a particular *context item*
- The initial context item (if any) is set outside the scope of the query

```
doc("ord.xml")/order/item
```

sets the context in the first step to the document node of order.xml

```
order/item
```

relies on the processor to provide the context (the `order` child of what?)



# Path Expressions and the Changing Context

context is set outside the query

```
doc("ord.xml")/
```

context is the document node of `order.xml`

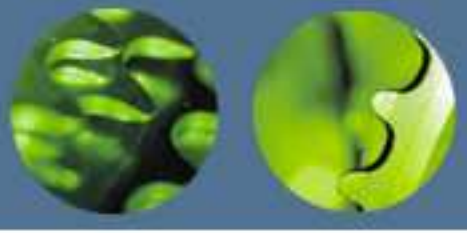
```
order/
```

context is the `order` element of `order.xml`

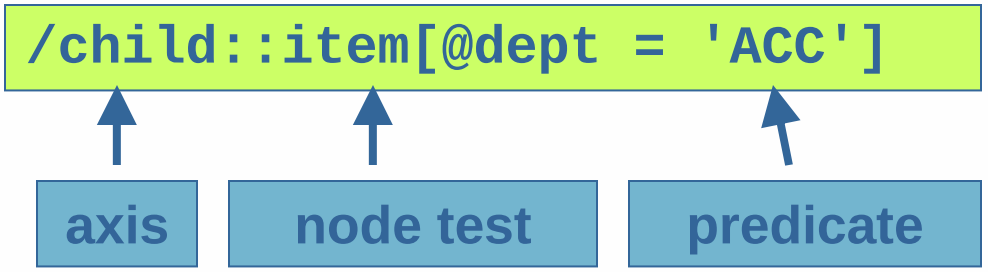
```
item
```

context is each `item` child of `order` (in turn)

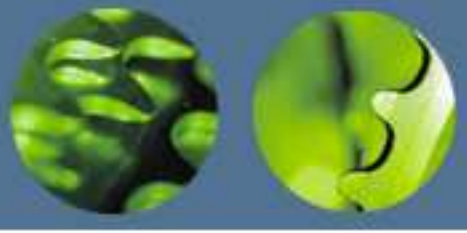
```
[@dept = 'ACC']
```



# Components of an Axis Step

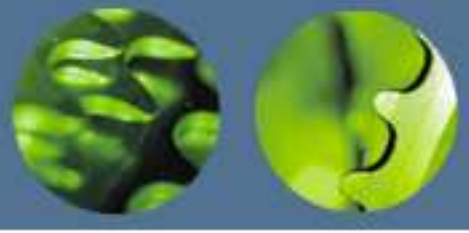



1. The axis (optional)
   - the direction to navigate
2. The node test
   - the nodes of interest by name or node kind
3. The predicates (optional and repeating)
   - the criteria used to filter nodes



# Axes

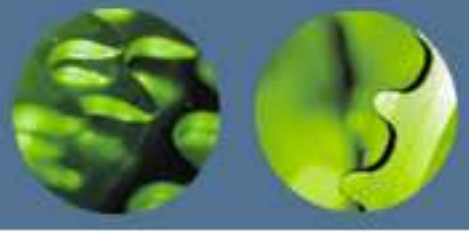
- Twelve axes allow you to specify the "direction" to navigate
  - e.g. **`child::, parent::, descendant::`**
- Their names are followed by `::`
  - some have abbreviations
- If none is specified, **`child::`** is the default



# child Axis

- Returns children
  - child elements, PIs, comments, text
  - but not attributes
- The default axis if none is specified

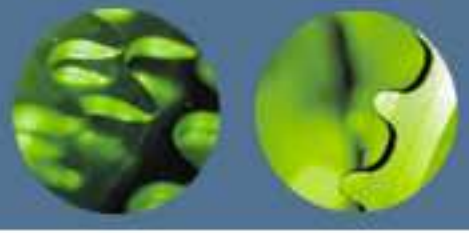
```
doc("ord.xml")/order/item
doc("ord.xml")/child::order/child::item
doc("ord.xml")/*/item
```



# attribute Axis

- Returns the attributes of an element
- Abbreviated with "@"

```
doc("ord.xml")/order/item/@dept
doc("ord.xml")/order/item/attribute::dept
doc("ord.xml")/order/item/@*
```

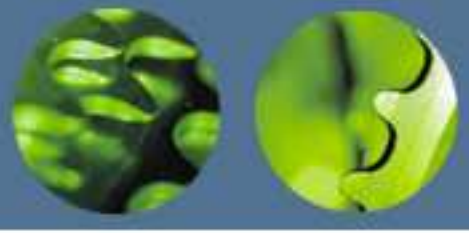


# descendant, descendant-or-self Axes

- Returns the children, the children's children, etc.
- Abbreviated by "//"

```
doc("ord.xml")//item
```

```
doc("ord.xml")/descendant-or-self::item
```

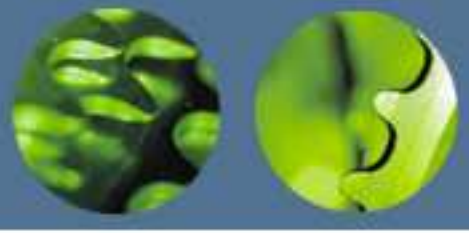


# parent Axis

- Returns the parent element of a node
- Applies to all node kinds
- Abbreviated with ".."

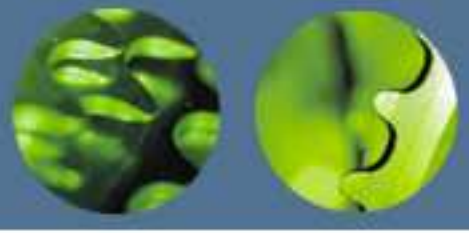
```
$prodNum/..
```

**returns the parent of the node bound to $prodNum**



# Other Axes

- **`self`**
  - the node itself (abbreviated as ".")
- **`ancestor`**, **`ancestor-or-self`**
  - the parent, the parent's parent, and so on
- **`following`** and **`preceding`**
  - all nodes that follow/precede it, in document order
- **`following-sibling`** and **`preceding-sibling`**
  - siblings that follow/precede it, in document order



# Node Tests

- Can consist of a:
  - node name (for elements/attributes)

```
doc("ord.xml")/order/item/@dept
```

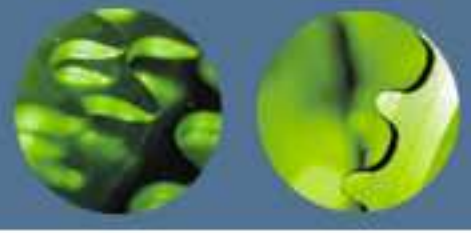
  - node kind

```
doc("cat.xml")/catalog/element()
doc("cat.xml")//number/text()
doc("cat.xml")//desc/node()
```

  - wildcard (*)

```
doc("ord.xml")/order/*/@*
```

all the attributes of all the element children of order



# Filter Expressions

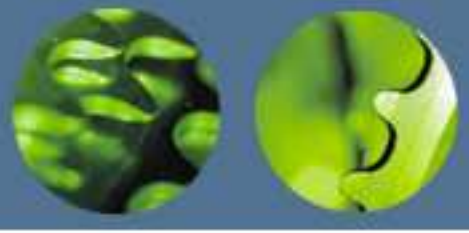
- Steps that use expressions instead of axes and node tests

```
doc("cat.xml")/catalog/product
```

```
$catDoc/catalog/product
```

```
product/(number | name)
```

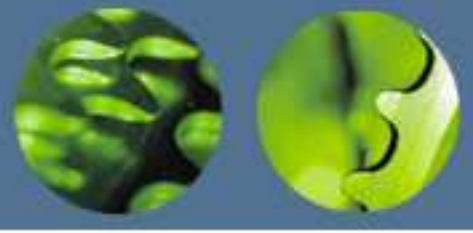
```
product/(if (desc) then desc else name)
```



# Predicates

- Filter nodes based on specific criteria
- Enclosed in square brackets [ and ]
- Zero, one or more in each step

```
doc("cat.xml")//product[number < 500]
```



# Predicates and Returned Elements

- Using **number** in a predicate does not mean that **number** elements are returned:

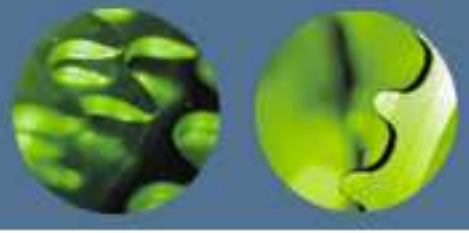
**All product elements whose number child is less than 500:**

```
product[number < 500]
```

**All number elements whose value is less than 500:**

```
product/number[. lt 500]
```

**A period (".") is used to indicate the context item itself**



# Predicates and Comparison Operators

- General comparisons vs. value comparisons

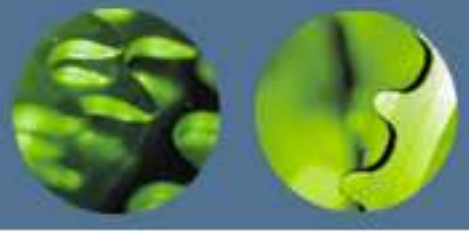
**All `products` that have only one `number` child, whose value is less than 500:**

```
product[number lt 500]
```

**All `products` that have at least one `number` child, whose value is less than 500:**

```
product[number < 500]
```

**may have other `number` children whose values are greater than 500**



# Predicates and Boolean Values

- Expression evaluates to a boolean value
  - effective boolean value (EBV) is used

All items that have a dept attribute that is equal to 'ACC':

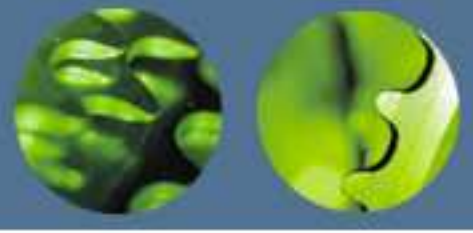
```
doc("ord.xml")//item[@dept = 'ACC']
```

true if the dept attribute exists and is equal to 'ACC'
false if the dept attribute exists and is not equal to 'ACC'
() if the dept attribute doesn't exist ==> converted to false

All items that have a dept attribute:

```
doc("ord.xml")//item[@dept]
```

the dept attribute if it exists ==> converted to true
() if the dept attribute doesn't exist ==> converted to false



# Using Position in Predicates

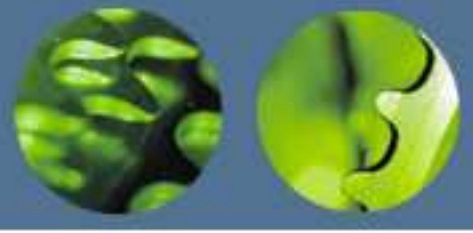
- Can use a number in the predicate to indicate the position of the child

**The 4th `product` child of `catalog`:**

```
catalog/product[4]
```

**The 4th child of `catalog` (regardless of its name):**

```
catalog/*[4]
```



# Using the `position` and `last` Functions

- **`position`** returns the position of the node in the current sequence

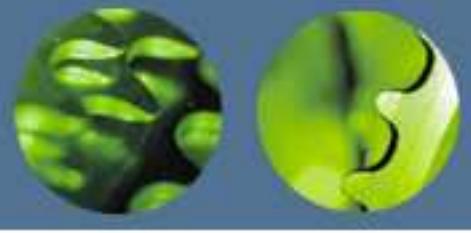
**The first three `product` children of `catalog`:**

```
catalog/product[position() < 4]
```

- **`last`** returns the number of items in the current sequence

**The last `product` child of `catalog`:**

```
catalog/product[last()]
```



# Multiple Predicates

- More than one predicate can be used to specify multiple constraints in a step
  - evaluated left to right

**Products whose number is less than 500 *and* whose department is ACC:**

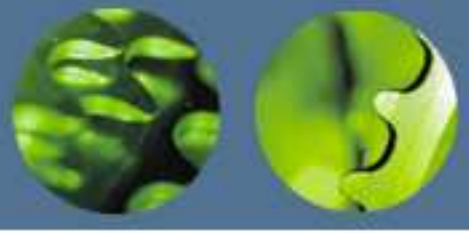
```
product[number < 500][@dept = "ACC"]
```

**Of the products whose department is 'ACC', select the 2nd one:**

```
product[@dept = "ACC"][2]
```

**Take the 2nd product, if it's in the ACC department, select it:**

```
product[2][@dept = "ACC"]
```



# More Complex Predicates

- Predicate can contain any expression

products whose department contains 'A':

```
product
  [contains(@dept, "A")]
```

products that have at least one child other than number :

```
product[* except number]
```

every other product :

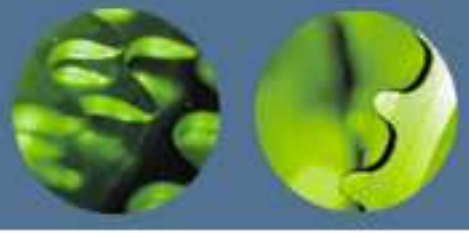
```
product
  [position() mod 2 = 0]
```

products that have desc children if the variable $descFilter is true, otherwise all products:

```
product[if ($descFilter)
   then desc else true()]
```

integers from one to a hundred that are divisible by 5:

```
(1 to 100)[. mod  5 = 0]
```



# Collections and Documents

## Collection `whitman`

### Collection `manuscripts`

- Document loc.00002.xml
- Document loc.00004.xml
- Document loc.00006.xml
- Document loc.00009.xml

### Collection `works`

#### Collection `leaves55`

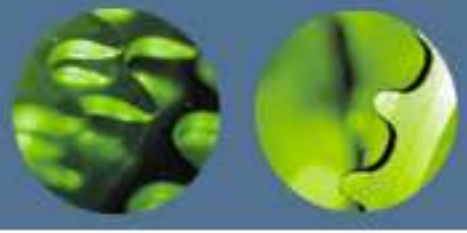
- Document ppp.00271.1.xml

. . .

#### Collection `leaves56`

- Document ppp.00237.13.xml

. . .



# The doc Function

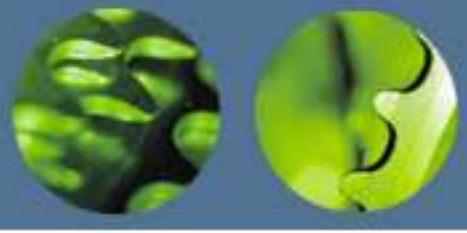
- References a single document via a URI
- Using some XML databases, the URI is a name assigned to that document in the DB
  - like a file system, may depend on context

```
doc("loc.00002.xml")
```

```
doc("/whitman/manuscripts/loc.00002.xml")
```

- Other processors will dereference the URI

```
doc("file:///C:/cat.xml")
doc("http://www.datypic.com/cat.xml")
```

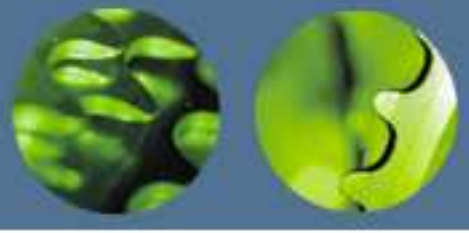


# Collections

- The **`collection`** function references a collection via a URI
- Returns a sequence of document nodes

```
collection("/whitman/works")
```

- Collections are implementation defined
  - for example:
    - Saxon accepts the URI of an XML document that lists the documents that make up the collection
    - MarkLogic accepts a URI that serves as the name of a collection defined within the database



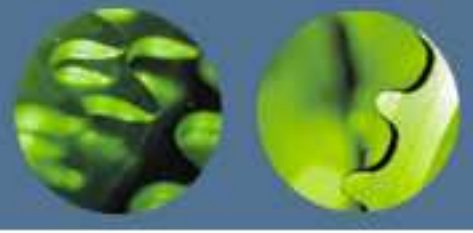
# Accessing Collections

- Calls to collection functions can be combined with path expressions

```
collection("/whitman/works")/TEI.2
```

- ...or iterated in FLWOR expressions

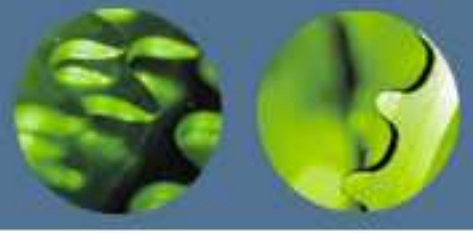
```
for $doc in
 collection("/whitman/manuscripts")
return $doc//relations
```



# Starting a Path with / or //

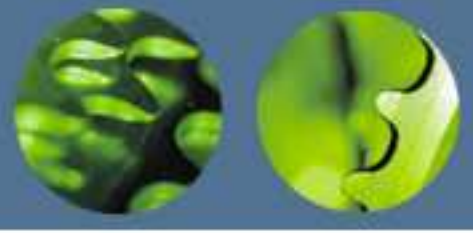
- "/" starts a path at the root element(s)
- Relies on the context item to be set outside the scope of the query
- if the context item is the **`ord.xml`** document node
  - **`/order`** will return the root element named **`order`**
  - **`//item`** will return all the all the elements named **`item`** in the document

# Adding Elements and Attributes



# 3 Ways to Add Elements/ Attributes to Results

- Including them from the input document
  - like most of our previous examples
- Using direct constructors
  - XML-like syntax
- Using computed constructors
  - special syntax using curly braces
  - allows for dynamic names

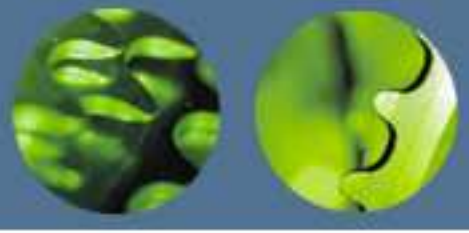


# Including from the Input Document

```
for $prod in
  doc("cat.xml")/catalog/product[@dept='ACC']
return $prod/name
```

```
<name language="en">Ten-Gallon Hat</name>
<name language="en">Golf Umbrella</name>
```

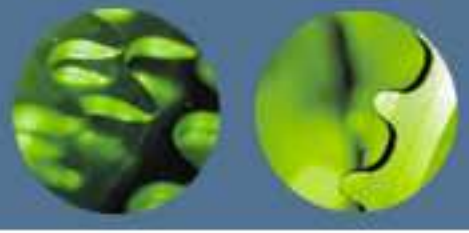
- **name** elements are included as is
  - along with their attributes (and children if any)
  - not just their atomic values
- no opportunity to change attributes, children, namespace



# Direct Element Constructor Example

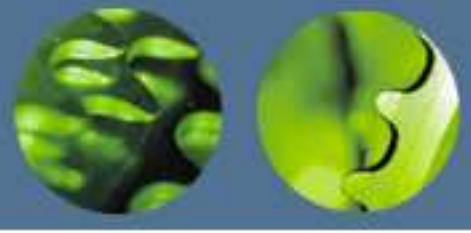
```
<html><h1>Product Catalog</h1>
  <ul>{
    for $prod in doc("cat.xml")/catalog/product
    return <li>#{data($prod/number)
                } is {data($prod/name)}</li>
  }</ul>
</html>
```

```
<html><h1>Product Catalog</h1>
  <ul>
    <li>#557 is Linen Shirt</li>
    <li>#563 is Ten-Gallon Hat</li> ...
  </ul>
  </html>
```



# Direct Element Constructors

- Use XML-like syntax
  - and follow the same rules (proper nesting, case sensitivity, etc.)
- Can contain:
  - literal content
  - other direct element constructors
  - enclosed expressions (in curly braces)
    - can evaluate to elements, attributes or atomic values
  - a mixture of all of the above

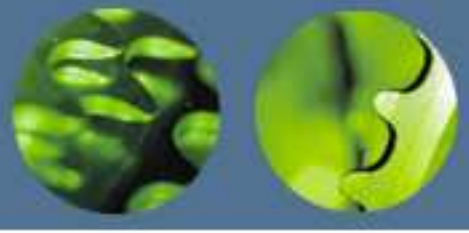


# Containing Literal Content

- All characters appearing outside curly braces are taken literally

```
<li>Product number {data($prod/number)}</li>
```

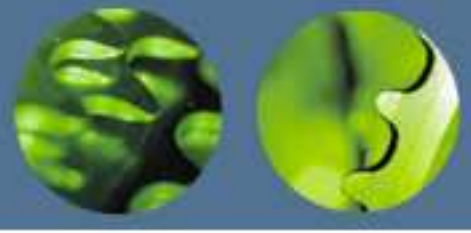
- Can contain:
  - character references, predefined entity references
  - whitespace (significant if combined with other chars)
- Cannot contain:
  - unescaped < and & characters
  - unescaped curly braces (double them to escape)



# Containing Other Direct Element Constructors

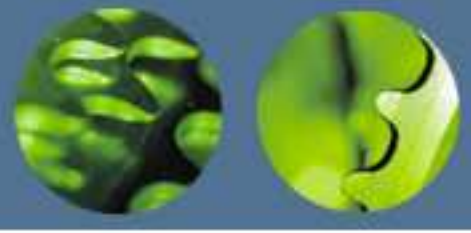
```
<html>
  <h1>Product Catalog</h1>
  <p>A <i>huge</i> list of {
          count(doc("cat.xml")//product)
        } products.</p>
</html>
```

- No curly braces, no special separators



# Containing Enclosed Expressions

- Enclosed in curly braces { and }
- Can evaluate to:
  - element nodes
    - they become children of the element
  - attribute nodes
    - they become attributes of the element
  - atomic values
    - they become character data content of the element
  - a combination of the above



# Enclosed Expressions Example

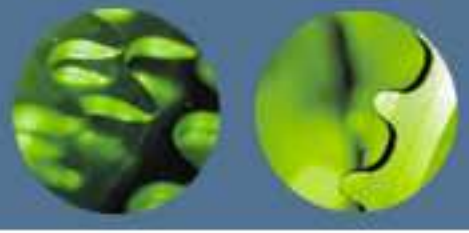
```
for $prod in doc("cat.xml")/catalog/product
return <li>{$prod/@dept}
                {concat("num", ": ")}
                                {$prod/number}</li>
```

attribute node becomes an attribute

atomic value becomes character data content

element node becomes child

```
<li dept="WMN">num: <number>557</number></li>
<li dept="ACC">num: <number>563</number></li>
<li dept="ACC">num: <number>443</number></li>
<li dept="MEN">num: <number>784</number></li>
```

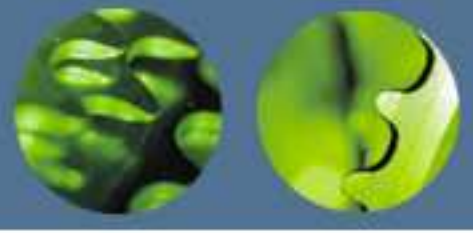


# Specifying Attributes Directly

- Attributes can also have XML-like syntax

```
<h1 class="itemHdr">Product Catalog</h1>,
<ul>{for $prod in doc("cat.xml")/catalog/product
      return <li class="{$prod/@dept}">
       {data($prod/name)}</li>
}</ul>
```

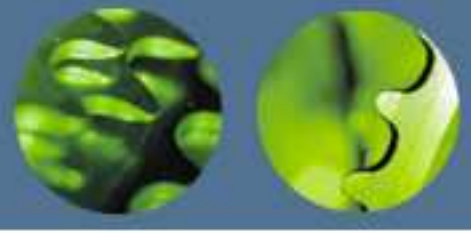
- Like element constructors, can contain:
  - literal content
  - enclosed expressions
    - but always evaluated to atomic values



# Use Case: Adding an Attribute to product

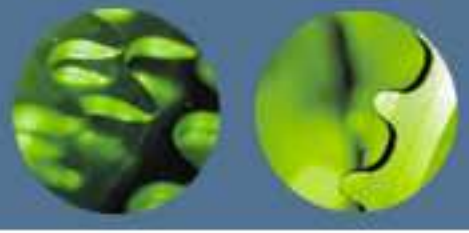
```
for $prod in doc("cat.xml")//product[@dept = 'ACC']
return <product id="{concat("P",$prod/number)}">
          {$prod/@*}
          {$prod/*}
       </product>
```

```
<product dept="ACC" id="P563">
 <number>563</number>
 <name language="en">Ten-Gallon Hat</name>
</product>
<product dept="ACC" id="P443">
 <number>443</number>
 <name language="en">Golf Umbrella</name>
</product>
```



# Computed Constructors

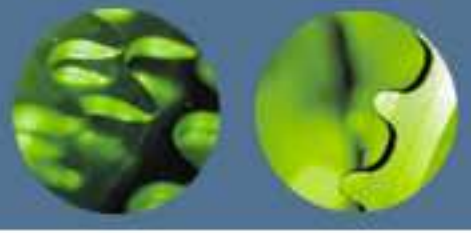
- Allow dynamic names and values
- Useful for:
  - copying elements from the input document but making minor changes to their content
    - e.g. add an **`id`** attribute to every element, regardless of name
  - turning content from the input document into element or attribute names
    - e.g. create an element whose name is the value of the **`dept`** attribute in the input document
  - looking up element names in a separate dictionary
    - e.g. for language translation



# Computed Constructor Simple Example

```
element product {
    attribute dept { "ACC" },
    element {concat("num","ber")}  { 563 },
    element name { attribute language { "en"},
                   "Ten-Gallon Hat"}
  }
```

```
<product dept="ACC">
  <number>563</number>
  <name language="en">Ten-Gallon Hat</name>
</product>
```

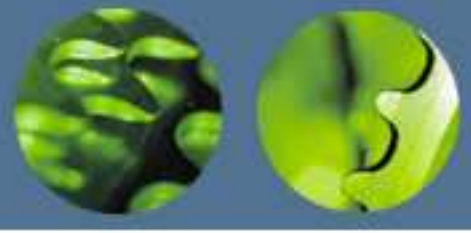


# Use Case: Turning Content into Markup

```
for $dept in distinct-values(
   doc("cat.xml")//product/@dept)
return element {$dept}
 {doc("cat.xml")//product[@dept = $dept]/name}
```

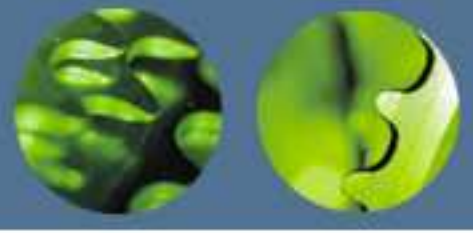
```
<WMN>
  <name language="en">Linen Shirt</name>
</WMN>
<ACC>
  <name language="en">Ten-Gallon Hat</name>
  <name language="en">Golf Umbrella</name>
</ACC>
<MEN>
  <name language="en">Rugby Shirt</name>
</MEN>
```

# Selecting and Filtering



# 2 Ways to Select

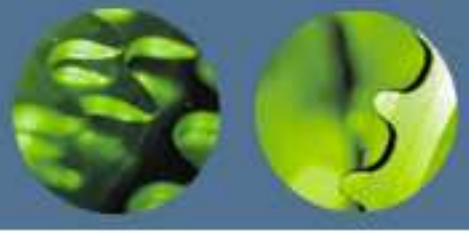
- Path Expressions
  - great if you just want to copy certain elements and attributes as is
- FLWOR Expressions
  - allow sorting
  - allow adding elements/attributes to results
  - more verbose, but can be clearer



# Clauses of a FLWOR Expression

- **`for`** clause
  - iteratively binds the **`$prod`** variable to each item returned by a path expression.
- **`let`** clause
  - binds the **`$prodDept`** variable to the value of the **`dept`** attribute
- **`where`** clause
  - selects nodes whose **`dept`** attribute is equal to "**`WMN`**" or "**`ACC`**"
- **`return`** clause
  - returns the **`name`** children of the selected nodes

```
for $prod in doc("cat.xml")//product
let $prodDept := $prod/@dept
where $prodDept = "ACC" or $prodDept = "WMN"
return $prod/name
```

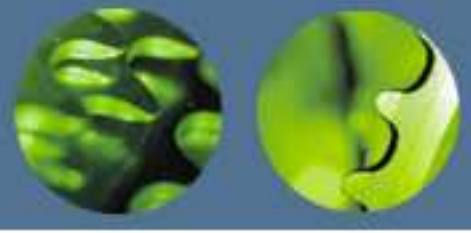


# `for` Clauses

- Iteratively binds the variable to each item returned by the **`in`** expression
- The rest of the expression is evaluated once for each item returned
- Multiple **`for`** clauses are allowed in the same FLWOR

**expression after `in` can evaluate to any sequence**

```
for $prod in doc("cat.xml")//product
```

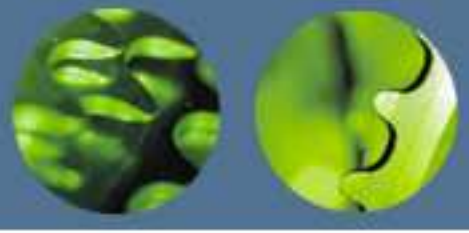


# Range Expressions

- Create sequences of consecutive integers
- Use **`to`** keyword
  - **`(1 to 5)`** evaluates to a sequence of 1, 2, 3, 4 and 5
- Useful in **`for`** clauses to iterate a specific number of times

```
for $i in (1 to 5)
...
```

```
for $i in (1 to $prodCount)
...
```

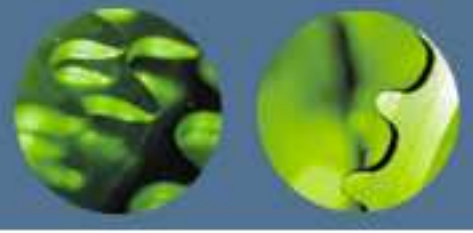


# Multiple Variables in a `for` Clause

- Use commas to separate multiple **`in`** expressions
  - or multiple **`for`** clauses
- Return clause evaluated for every combination of variable values

```
for $i in (1, 2), $j in (11, 12)
return <eval>i is {$i} and j is {$j}</eval>
```

```
<eval>i is 1 and j is 11</eval>
<eval>i is 1 and j is 12</eval>
<eval>i is 2 and j is 11</eval>
<eval>i is 2 and j is 12</eval>
```

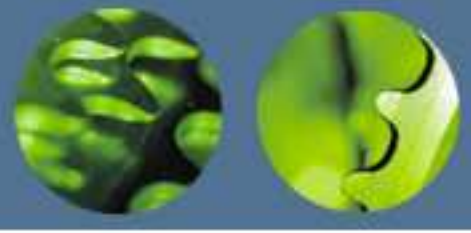


# Positional Variables in `for` Clauses

- Positional variable keeps track of the iteration number
- Use **`at`** keyword

```
for $prod at $i in doc("cat.xml")//
  product[@dept = "ACC" or @dept = "WMN"]
return <eval>{$i}. {data($prod/name)}</eval>
```

```
<eval>1. Linen Shirt</eval>
<eval>2. Ten-Gallon Hat</eval>
<eval>3. Golf Umbrella</eval>
```



# let Clauses

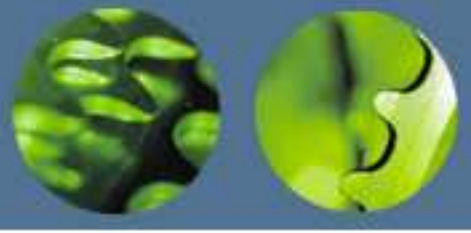
- Convenient way to bind a variable
  - avoids repeating the same expression many times
- Does not result in iteration

```
for $i in (1 to 3)
return <eval>{$i}</eval>
```

```
<eval>1</eval>
<eval>2</eval>
<eval>3</eval>
```

```
let $i := (1 to 3)
return <eval>{$i}</eval>
```

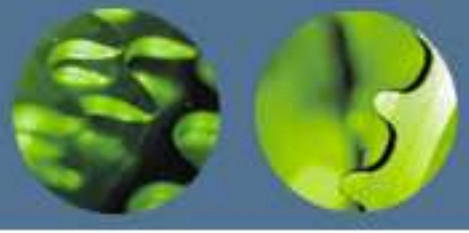
```
<eval>1 2 3</eval>
```



# Multiple for and let clauses

- **for** and **let** can be repeated and combined

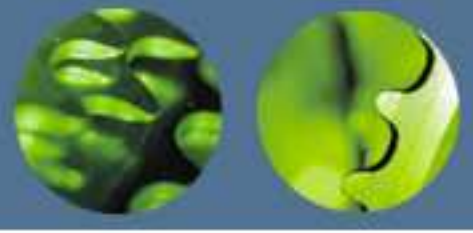
```
let $catDoc := doc("cat.xml")
for $prod in $catDoc//product
let $prodDept := $prod/@dept
where $prodDept = "ACC" or $prodDept = "WMN"
return $prod/name
```



# where Clause

- Used to filter results
- Can contain many subexpressions
- Evaluates to a boolean value
  - effective boolean value is used
- If **`true`**, return clause is evaluated

```
where $prod/number > 100
  and starts-with($prod/name, "L")
  and exists($prod/colorChoices)
  and ($prodDept="ACC" or $prodDept="WMN")
```



# return Clause

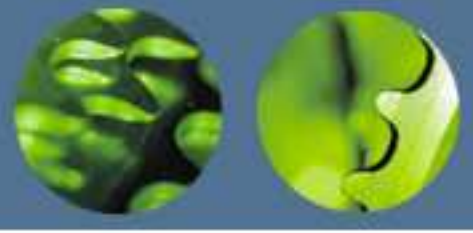
- The value that is to be returned

```
for $prod in doc("cat.xml")//product
return $prod/name
```

- Single expression only
  - can combine multiple expressions into a sequence

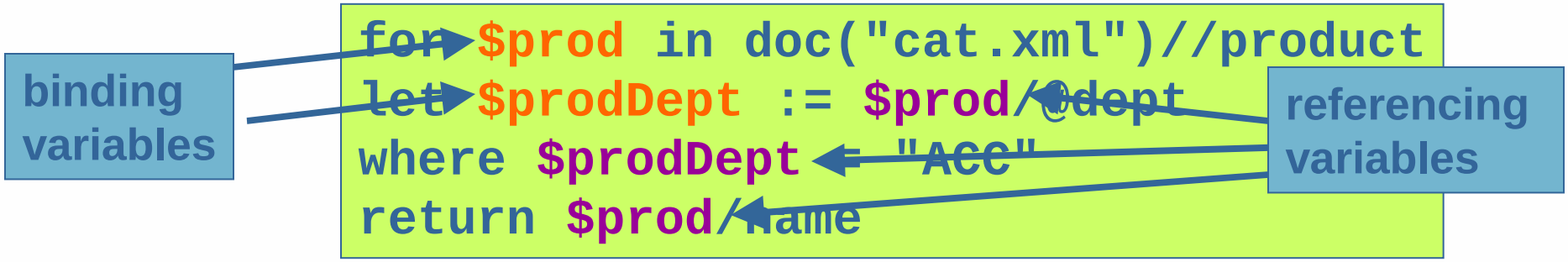
```
return <a>{$i}</a>
       <b>{$j}</b>
```

```
return (<a>{$i}</a>,
        <b>{$i}</b>)
```

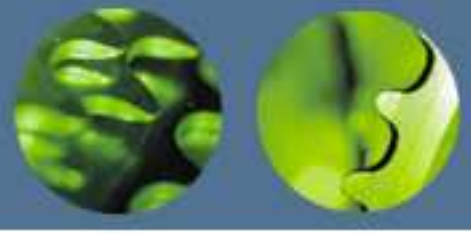


# Variable Binding and Referencing

- Variables are *bound* in the let/for clauses
- Once bound, variables can be *referenced* anywhere in the FLWOR




- Values cannot be changed once bound
  - e.g. no **`let $count := $count + 1`**

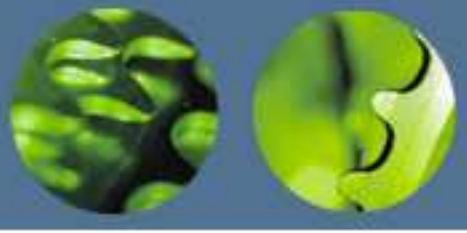


# Quantified Expressions

- To determine whether some or all items in a sequence meet a criteria
- Evaluates to a boolean value
- Use **`some`** or **`every`** with **`satisfies`**

```
some $dept in doc("cat.xml")//product/@dept
satisfies ($dept = "ACC")
```

```
every $dept in
doc("cat.xml")//product/@dept
satisfies ($dept = "ACC")
```



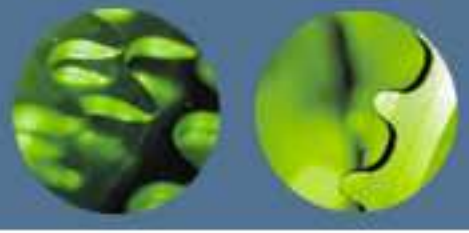
# Selecting Distinct Values

- Use the **`distinct-values`** function

```
distinct-values(
   doc("cat.xml")//product/@dept)
```

```
WMN,ACC,MEN
```

- Only works on atomic values or nodes with single atomic values
- Only accepts one argument
  - for a combination of multiple values, call **`distinct-values`** more than once using multiple **`for`** clauses



# Selecting Combinations of Distinct Values

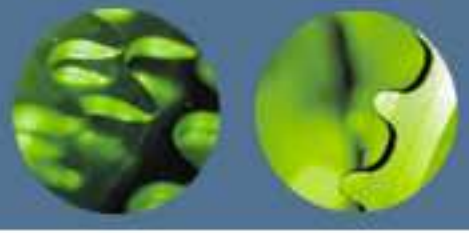
```
let $prods := doc("cat.xml")//product
for $d in distinct-values($prods/@dept),
    $n in distinct-values($prods[@dept=$d]/number)
return
  <result dept="{$d}" number="{$n}"/>
```

$d is bound to each distinct department

$n is bound to each distinct number within a department

```
<result dept="WMN" number="557"/>
<result dept="ACC" number="563"/>
<result dept="ACC" number="443"/>
<result dept="MEN" number="784"/>
```

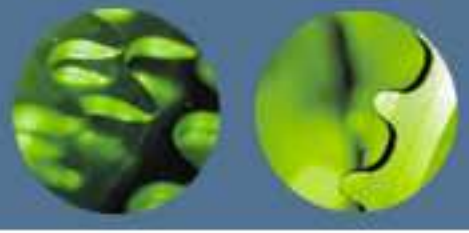
# Sorting Results



# `order by` Clause

- Only way to sort results in XQuery
- Use **`order by`** before **`return`** clause
- Order by
  - atomic values, or
  - nodes that contain individual atomic values
- Can specify multiple values to sort on

```
for $item in doc("ord.xml")//item
order by $item/@dept, $item/@num
return $item
```



# More Complex order by Clauses

- Not limited to a simple path expression
  - function calls

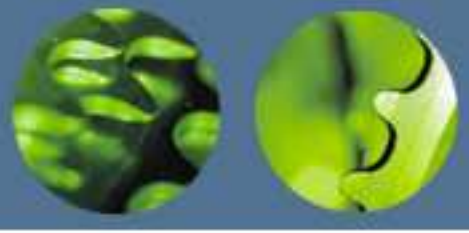
```
order by substring($item/@dept, 2, 2)
```

  - conditional expressions

```
order by (if ($item/@color) then
$item/@color else "unknown")
```

  - lookup in a separate document

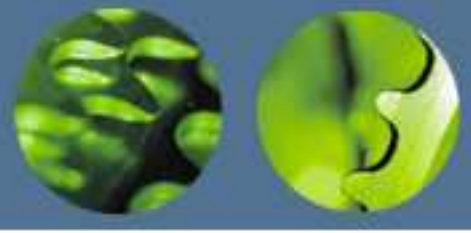
```
order by doc("cat.xml")//product[number =
$item/@num]/name
```



# Reversing the Order

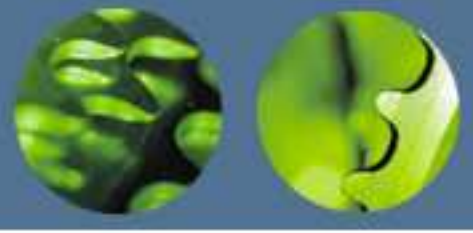
- Reverse the order of a sequence using the **`reverse`** function
- Works for nodes and atomic values

```
reverse( (6, 3, 2))  →  (2, 3, 6)
```



# Document Order

- The document order of a set of nodes is:
  - the document node itself
  - each element node in order of the appearance of its first tag, followed by:
    - its attribute nodes, in an implementation-defined order
    - its children (text nodes, child element nodes, comment nodes, and processing-instruction nodes in the order they appear

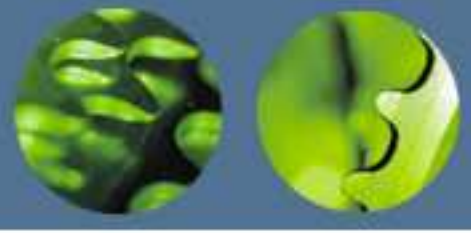


# When Document Order is Applied

- Certain expressions return results in document order:
  - path expressions
  - union, except and intersect operators
- Beware of inadvertent re-sorting

```
let $sortedProds := for $prod in
doc("cat.xml")//product
                    order by $prod/number
                    return $prod
for $prodName in $sortedProds/name
return <li>{string($prodName)}</li>
```

path expression resorts



# Comparing on Document Order

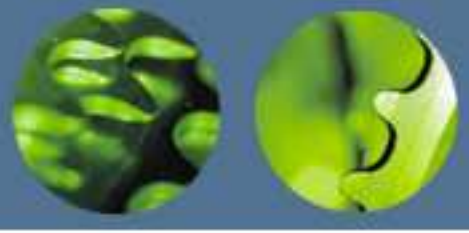
- To compare nodes based on document order, use
  - **<<** for precedes
  - **>>** for follows

```
doc("cat.xml")//product[1] <<
doc("cat.xml")//product[2]
```

**returns true**

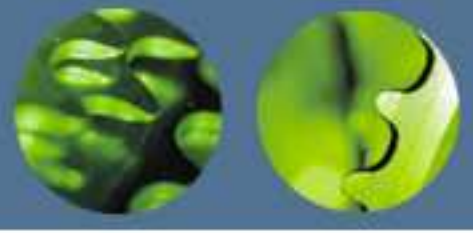
- Works for nodes only
  - no document order on atomic values

# Combining and Joining Results



# Joins

- Combining two or more input documents into one result set
- Another use for multiple **`for`** clauses



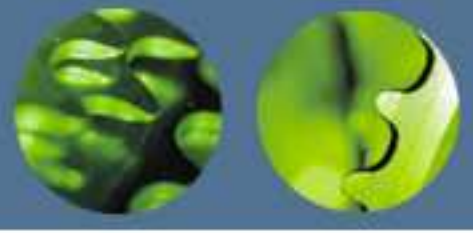
# Two-Way Join in a Predicate

access order document

```
for $item in doc("ord.xml")//item,
  $product in
    doc("cat.xml")//product[number=$item/@num]
return
  <item num="{$item/@num}"
        name="{$product/name}"
        quan="{$item/@quantity}"/>
```

join item numbers to product numbers

```
<item num="557" name="Linen Shirt" quan="1"/>
<item num="563" name="Ten-Gallon Hat" quan="1"/>
<item num="443" name="Golf Umbrella" quan="2"/>
<item num="784" name="Rugby Shirt" quan="1"/>
<item num="784" name="Rugby Shirt" quan="1"/>
<item num="557" name="Linen Shirt" quan="1"/>
```

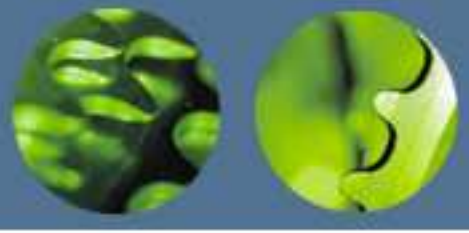


# Two-Way Join in a where Clause

```
for $item in doc("ord.xml")//item,
    $product in doc("cat.xml")//product
where $item/@num = $product/number
return
  <item num="{$item/@num}"
        name="{$product/name}"
        quan="{$item/@quantity}"/>
```

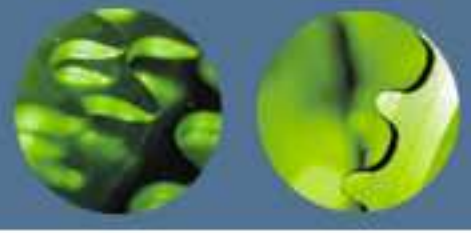
join in where clause

```
<item num="557" name="Linen Shirt" quan="1"/>
<item num="563" name="Ten-Gallon Hat" quan="1"/>
<item num="443" name="Golf Umbrella" quan="2"/>
<item num="784" name="Rugby Shirt" quan="1"/>
<item num="784" name="Rugby Shirt" quan="1"/>
<item num="557" name="Linen Shirt" quan="1"/>
```



# Outer Joins

- All items from the first input document, and their matches from the second document *if available*
- For example, a list of products, and their prices if available
- Use two FLWOR expressions



# Outer Join

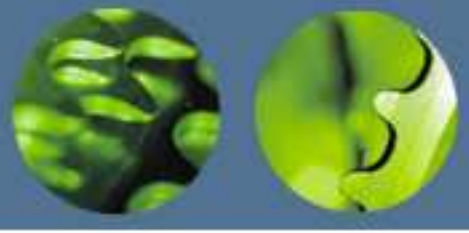
```
for $product in doc("cat.xml")//product
return
  <product
   number="{$product/number}"
   price="{for $price in
              doc("prc.xml")//prices//prod
            where $product/number = $price/@num
            return $price/price}"/>
```

embedded FLWOR

join

```
<product number="557" price="29.99"/>
<product number="563" price="69.99"/>
<product number="443" price="39.99"/>
<product number="784" price=""/>
```

no corresponding price



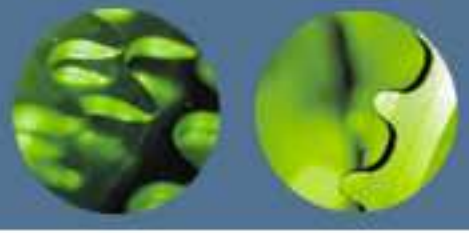
# Combining Sequences

- concatenation
  - duplicates are not removed, order is retained

```
($seq1, $seq2)
```

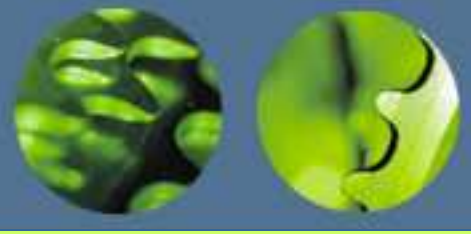
- **`union`**, **`intersect`** and **`except`**
  - duplicates are removed
  - results are sorted in document order
  - work on sequences of *nodes* only, not atomic values

```
$seq1 union $seq2
$seq1 | $seq2
$seq1 intersect $seq2
$seq1 except $seq2
```



# Grouping

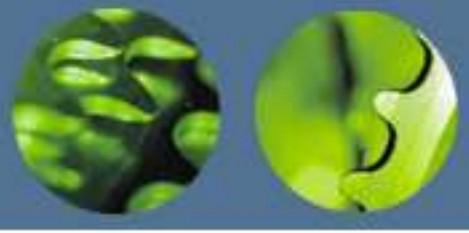
- Summarize or organize information into categories
- For example:
  - group all the items in an order by department
  - put the items for each department within a **dep** element whose **code** attribute is the department number



# Grouping By Department

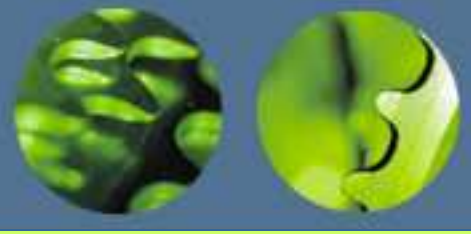
```
for $d in
  distinct-values(doc("ord.xml")//item/@dept)
let $items := doc("ord.xml")//item[@dept = $d]
order by $d
return <dep code="{$d}">{$items}</dep>
```

```
<dep code="ACC">
  <item dept="ACC" num="443" quantity="2"/>
  <item dept="ACC" num="563" quantity="1"/>
</dep>
<dep code="MEN">
  <item dept="MEN" num="784" quantity="1" color="blue/white"/>
  <item dept="MEN" num="784" quantity="1" color="blue/red"/>
</dep>
<dep code="WMN">
  <item dept="WMN" num="557" quantity="1" color="beige"/>
  <item dept="WMN" num="557" quantity="1" color="sage"/>
</dep>
```



# Aggregating

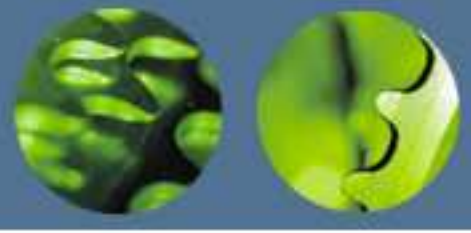
- Make summary calculations on grouped data
- Useful functions
  - **`sum, avg, max, min, count`**
- For example:
  - for each department, find the number of distinct items and the total quantity of items



# Aggregating By Department

```
for $d in
  distinct-values(doc("ord.xml")//item/@dept)
let $items := doc("ord.xml")//item[@dept = $d]
order by $d
return <department code="{$d}"
  numItems="{count($items)}"
  distinctItemNums="{
    count(distinct-values($items/@num))}"
  totQuant="{sum($items/@quantity)}"/>
```

```
<department code="ACC" numItems="2"
            distinctItemNums="2" totQuant="3"/>
<department code="MEN" numItems="2"
            distinctItemNums="1" totQuant="2"/>
<department code="WMN" numItems="2"
            distinctItemNums="1" totQuant="2"/>
```

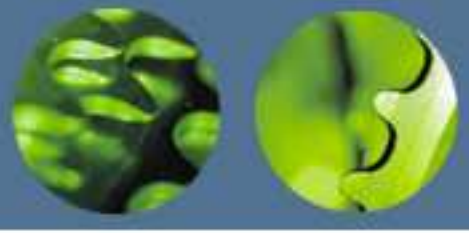


# Aggregating By Department *and* Number

```
for $d in
  distinct-values(doc("ord.xml")//item/@dept)
for $n in distinct-values(
   doc("ord.xml")//item[@dept=$d]/@num)
let $items :=
    doc("ord.xml")//item[@dept=$d and @num=$n]
order by $d, $n
return <group dept="{$d}" num="{$n}"
          numItems="{count($items)}"
          totQuant="{sum($items/@quantity)}"/>
```

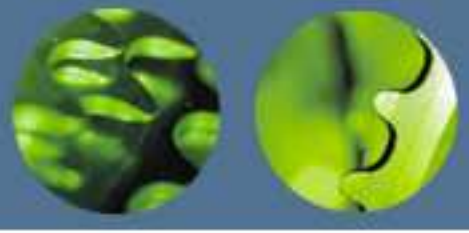
```
<group dept="ACC" num="443" numItems="1" totQuant="2"/>
<group dept="ACC" num="563" numItems="1" totQuant="1"/>
<group dept="MEN" num="784" numItems="2" totQuant="2"/>
<group dept="WMN" num="557" numItems="2" totQuant="2"/>
```

# Namespaces in XML



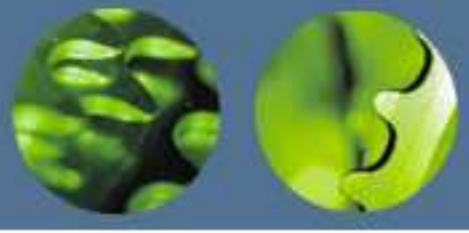
# Namespaces

- Agenda
  - The purpose of namespaces
  - Namespace declarations
  - Name terminology
  - Namespaces and attributes



# The Purpose of Namespaces

- Disambiguate names used in many contexts
- Identify the source of the definition/standard to which it belongs



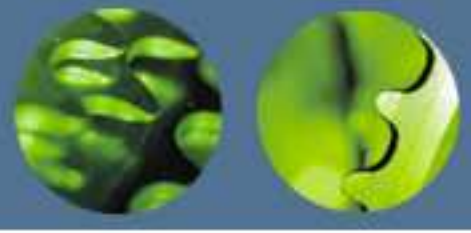
# Namespace Example

Namespace declaration

Namespace name

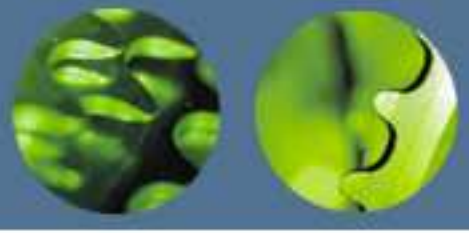
```
<prod:product
      xmlns:prod="http://datypic.com/prod">
  <prod:number>557</prod:number>
  <prod:size system="US">10</prod:size>
</prod:product>
```

Namespace prefix



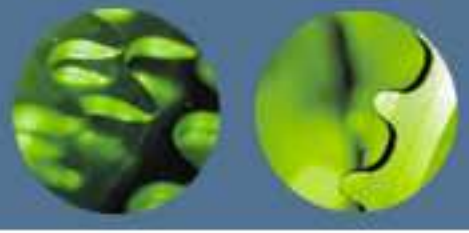
# Namespace Names

- Namespace names are URIs
  - this does not necessarily mean they can be dereferenced
- URIs include
  - URLs, e.g. `http://datypic.com/prod`
  - URNs, e.g. `urn:prod:datypic`



# Namespace Name Rules

- Namespace names are case-sensitive
  - two seemingly equivalent URIs are not the same as namespaces
- In reality, many text strings are valid relative URI references, so anything goes
- Relative URI references are discouraged
  - `../prod` does not really disambiguate

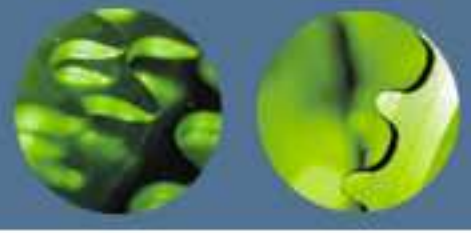


# Namespace Declarations

- Namespace declarations map:
  - prefixes (e.g. `prod`) to
  - namespaces (`http://datypic.com/prod`)

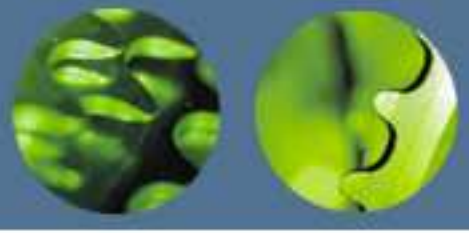
```
xmlns:prod="http://datypic.com/prod"
```

- Why prefixes?
  - shorter and more convenient
  - namespaces can contain characters not allowed in XML names



# Prefix Rules

- Must follow the rules for XML names
  - start with letter or underscore
  - contain letters, digits, _, -, .
- Keep them reasonably short for clarity
- Following conventions is better, e.g.
  - **`xs`** or **`xsd`** for schemas
  - **`xsl`** for XSLT stylsheets
  - **`wsdl`** for Web Services Description Language

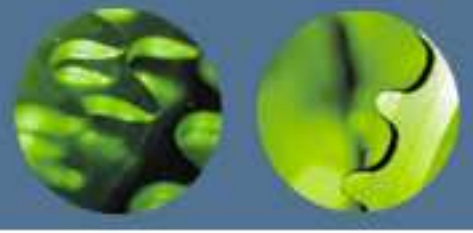


# Prefixes are Technically Irrelevant

```
<prod:product
      xmlns:prod="http://datypic.com/prod">
  <prod:number>557</prod:number>
  <prod:size system="US">10</prod:size>
</prod:product>
```

EQUALS

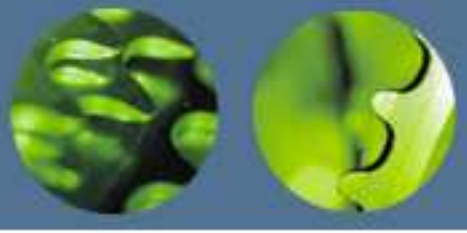
```
<foo:product
      xmlns:foo="http://datypic.com/prod">
  <foo:number>557</foo:number>
  <foo:size system="US">10</foo:size>
</foo:product>
```



# Multiple Namespace Declarations

- Multiple namespace declarations can appear in the same document

```
<ord:order
    xmlns:ord="http://datypic.com/ord"
    xmlns:prod="http://datypic.com/prod">
  <ord:number>123ABBCC123</ord:number>
  <ord:items>
    <prod:product>
      <prod:number>557</prod:number>
    </prod:product>
  </ord:items>
</ord:order>
```

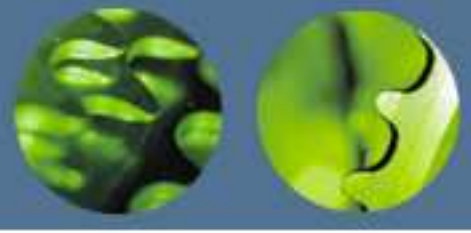


# Default Namespace Declarations

- Default namespace declarations do not use a prefix

```
xmlns="http://datypic.com/prod"
```

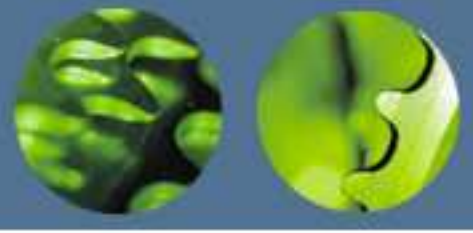
- All unprefixed elements are considered to be in the default namespace



# Default Namespace Declaration Example

- **product** and its child **number** are in the "prod" namespace (they're unprefixed)

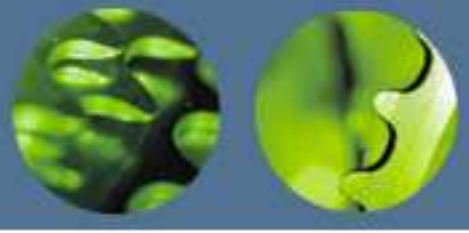
```
<ord:order
    xmlns:ord="http://datypic.com/ord"
    xmlns="http://datypic.com/prod">
  <ord:number>123ABBCC123</ord:number>
  <ord:items>
    <product>
      <number>557</number>
    </product>
  </ord:items>
</ord:order>
```



# Location of Namespace Declarations

- Namespace declarations can appear on any element in the document

```
<order xmlns="http://datypic.com/ord">
  <number>123ABBCC123</number>
  <items>
    <prod:product
      xmlns:prod="http://datypic.com/prod">
      <prod:number>557</prod:number>
    </prod:product>
  </items>
</order>
```



# Scope of Namespace Declarations

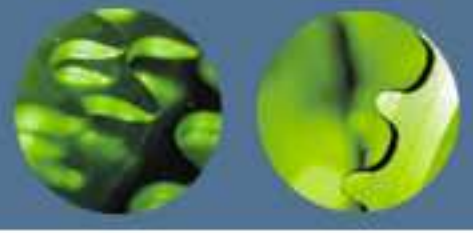
- The scope is the element and its children

scope of ord

scope of prod

```
<order xmlns="http://datypic.com/ord">
  <number>123ABBCC123</number>
  <items>
    <prod:product
      xmlns:prod="http://datypic.com/prod">
      <prod:number>557</prod:number>
    </prod:product>
  </items>
</order>
```

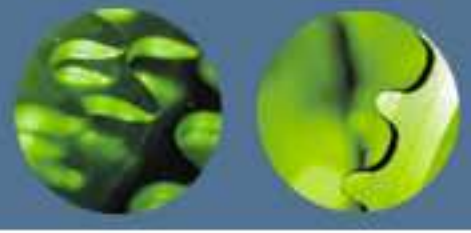
Illegal to use prod prefix here



# Overriding Namespace Declarations

- Second default namespace declaration overrides the first, in the scope of the **`product`** element

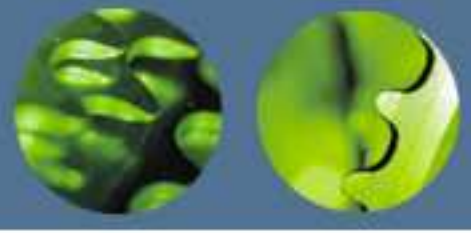
```
<order xmlns="http://datypic.com/ord">
  <number>123ABBCC123</number>
  <items>
    <product xmlns="http://datypic.com/prod">
      <number>557</number>
    </product>
  </items>
</order>
```



# Name Terminology

- Prefixed vs. unprefixed names

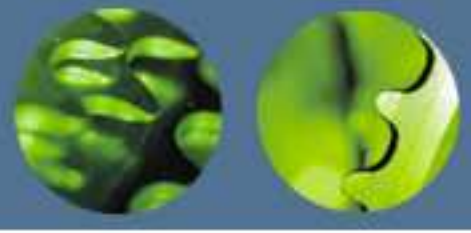
```
<ord:order
   xmlns:ord="http://datypic.com/ord"
   xmlns="http://datypic.com/prod">
  <ord:number>123ABBCC123</ord:number>
  <ord:items>
    <product>
      <number>557</number>
    </product>
  </ord:items>
</ord:order>
```



# Name Terminology

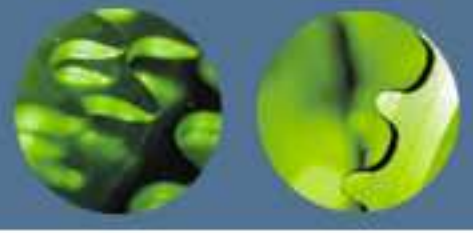
- Qualified vs. unqualified names

```
<order
   xmlns:ord="http://datypic.com/ord">
  <number>123ABBCC123</number>
  <ord:items>
    <product xmlns="http://datypic.com/prod">
      <number>557</number>
    </product>
  </ord:items>
</order>
```



# Name Terminology

- Local names
  - the non-namespace part of a name
  - for example, `product` in `prod:product`
- NCName (non-colonized name)
  - any name that follows the rules for XML names and does not contain a colon
  - for example, local names and prefixes

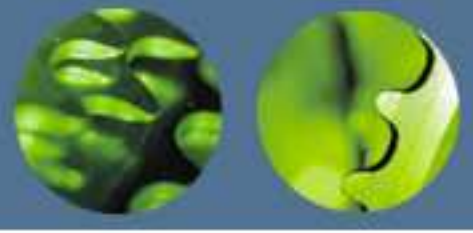


# Attributes and Namespaces

- Attributes can be prefixed
  - these are called global attributes
  - usually belong to a namespace other than their parent element

```
<product xmlns:prod="http://datypic.com/prod">
  <number>557</number>
  <size prod:system="US">10</size>
</product>
```

`system` attribute is in the prod namespace



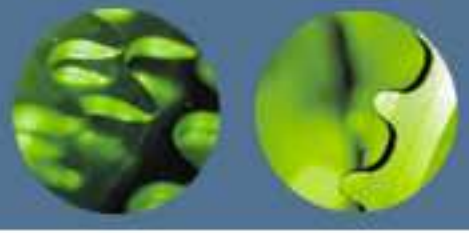
# Attributes and Default Namespaces

- Attributes are *not* affected by default namespace declarations
  - unlike elements

```
<product xmlns="http://datypic.com/prod">
  <number>557</number>
  <size system="US">10</size>
</product>
```

`system` attribute is not in a namespace

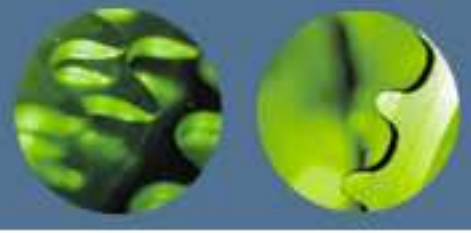
# Namespaces in XQuery



# A Product Catalog with a Namespace

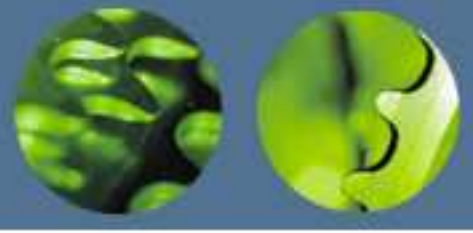
- ncat.xml

```
<catalog xmlns="http://datypic.com/cat"
         xmlns:prod="http://datypic.com/prod">
  <number>1446</number>
  <prod:product>
    <prod:number>563</prod:number>
    <prod:name language="en">Ten-Gallon
          Hat</prod:name>
  </prod:product>
</catalog>
```



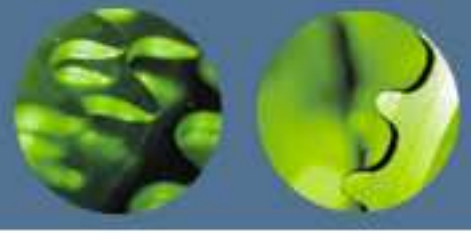
# Qualified Names

- Names in XQuery queries are namespace-qualified:
  - elements and attributes
    - from input documents, newly constructed elements
  - functions
  - types
  - variables



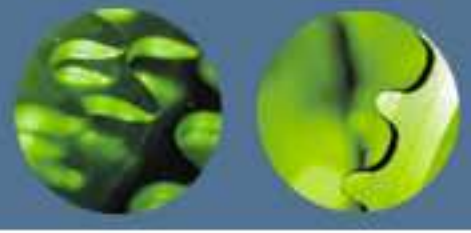
# Built-in Prefixes and Namespaces

| Prefix | Namespace | Uses |
|---|---|---|
| `xml` | `http://www.w3.org/XML/1998/namespace` | XML attributes such as `xml:lang` and `xml:space`. |
| `xs` | `http://www.w3.org/2001/XMLSchema` | XML Schema built-in types |
| `xsi` | `http://www.w3.org/2001/XMLSchema-instance` | XML Schema instance attributes such as `xsi:type` and `xsi:nil`. |
| `fn` | `http://www.w3.org/200?/??/xpath-functions` | All built-in functions |
| `local` | `http://www.w3.org/200?/??/xquery-local-functions` | locally declared functions that are not in a specific namespace |



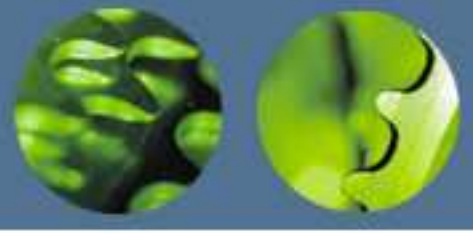
# Declaring Namespaces in Queries

- 2 ways:
  - in the query prolog
  - in a direct element constructor



# Declaring a Namespace in the Prolog

- In scope throughout the query body
- If it associated with a prefix:
  - prefix can be used with any name
- If it is a default element namespace declaration:
  - applies to elements, types
    - *even in path expressions* (unlike in XSLT)
  - not to variables, functions

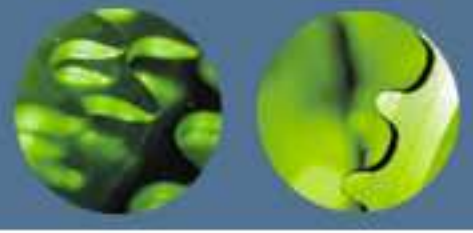


# Declaring a Namespace in the Prolog Example

```
declare default element namespace
                    "http://datypic.com/catreport";
declare namespace cat = "http://datypic.com/cat";
declare namespace prd = "http://datypic.com/prod";
<catReport> {
  for $product in
      doc("ncat.xml")/cat:catalog/prd:pr
  return <lineItem>
           <prd:newEl>{$product/prd:name
           }</prd:newEl>
         </lineItem>
} </catReport>
```

used for some result elements

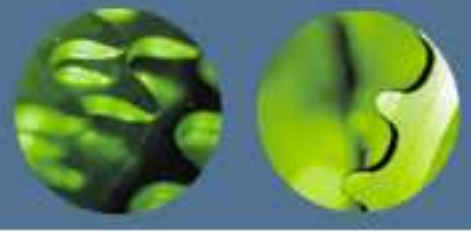
used for input elements



# Declaring a Namespace in the Prolog Result

```
<catReport xmlns="http://datypic.com/catreport">
 <lineItem>
   <prd:newEl xmlns:prd="http://datypic.com/prod">
   <prod:name xmlns="http://datypic.com/cat"
              xmlns:prod="http://datypic.com/prod"
          language="en">Ten-Gallon Hat</prod:name>
    </prd:newEl>
   </lineItem>
</catReport>
```

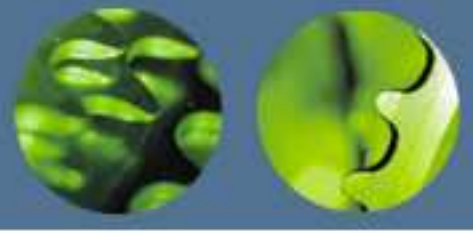
– Note proliferation of namespace declarations, including ones that are not used



# Declaring a Namespace in a Direct Constructor

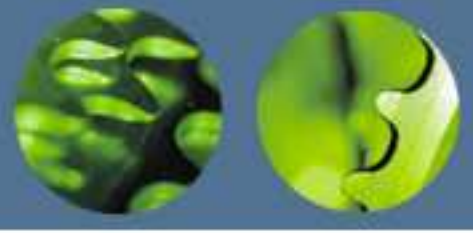
- Uses XML-like syntax
- Must be static
  - unlike attributes, value cannot be expressed as an enclosed expression
- Scope is the element being constructed

```
<catReport xmlns="http://datypic.com/catreport"
           xmlns:cat="http://datypic.com/cat"...
```



# Declaring a Namespace in a Direct Constructor

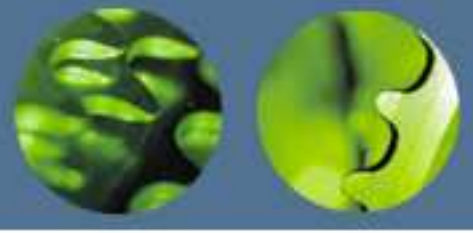
```
<catReport xmlns="http://datypic.com/catreport"
           xmlns:cat="http://datypic.com/cat"
           xmlns:prd="http://datypic.com/prod"> {
  for $product in
    doc("ncat.xml")/cat:catalog/prd:product
  return <lineItem>
           <prd:newEl> {$product/prd:name}
              </prd:newEl>
         </lineItem>
} </catReport>
```



# Declaring a Namespace in a Constructor Result

```
<catReport xmlns:prd="http://datypic.com/prod"
           xmlns:cat="http://datypic.com/cat"
           xmlns="http://datypic.com/catreport">
 <lineItem>
  <prd:newEl>
   <prod:name xmlns="http://datypic.com/cat"
              xmlns:prod="http://datypic.com/prod"
       language="en">Ten-Gallon Hat</prod:name>
  </prd:newEl>
 </lineItem>
</catReport>
```

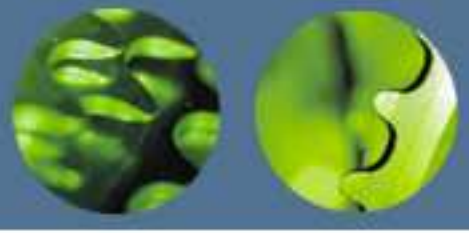
- Same results as previous example
  - but namespace declarations are slightly different



# Eliminating Namespace Declarations in Results

- Use same prefixes as in input documents
- Declare namespaces in prolog that do not appear in results
- Use copy-namespaces no-preserve, inherit

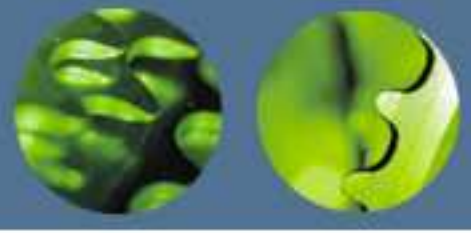
```
declare copy-namespaces no-preserve, inherit;
declare namespace cat = "http://datypic.com/cat";
<catReport xmlns="http://datypic.com/catreport"
           xmlns:prod="http://datypic.com/prod"> {
  for $product in
    doc("ncat.xml")/cat:catalog/prod:product
  return <lineItem>
           <prod:newEl> {$product/prod:name}
              </prod:newEl>
         </lineItem>
} </catReport>
```



# Eliminating Namespace Declarations in Results

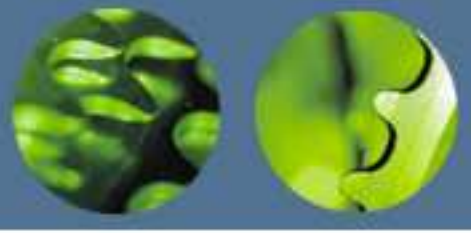
```
<catReport xmlns:prod="http://datypic.com/prod"
           xmlns="http://datypic.com/catreport">
   <lineItem>
      <prod:newEl>
         <prod:name language="en">Ten-Gallon
         Hat</prod:name>
      </prod:newEl>
   </lineItem>
</catReport>
```

# Functions



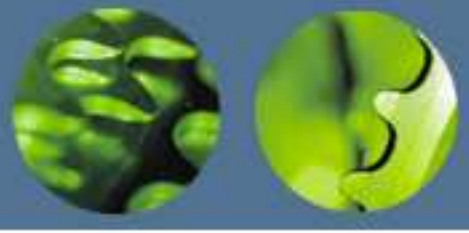
# Functions

- Built-in functions
  - over 100 functions built into XQuery
  - names do not need to be prefixed when called
- User-defined functions
  - defined in the query or in a separate module
  - names must be prefixed



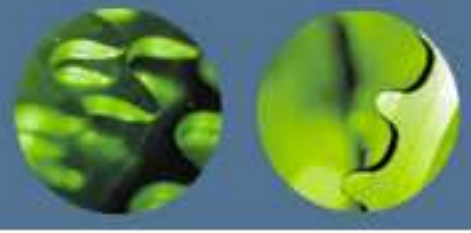
# Built-In Functions: A Sample

- String-related
  - **`substring, contains, matches, concat, normalize-space, tokenize`**
- Date-related
  - **`current-date, month-from-date, adjust-time-to-timezone`**
- Number-related
  - **`round, avg, sum, ceiling`**
- Sequence-related
  - **`index-of, insert-before, reverse, subsequence, distinct-values`**



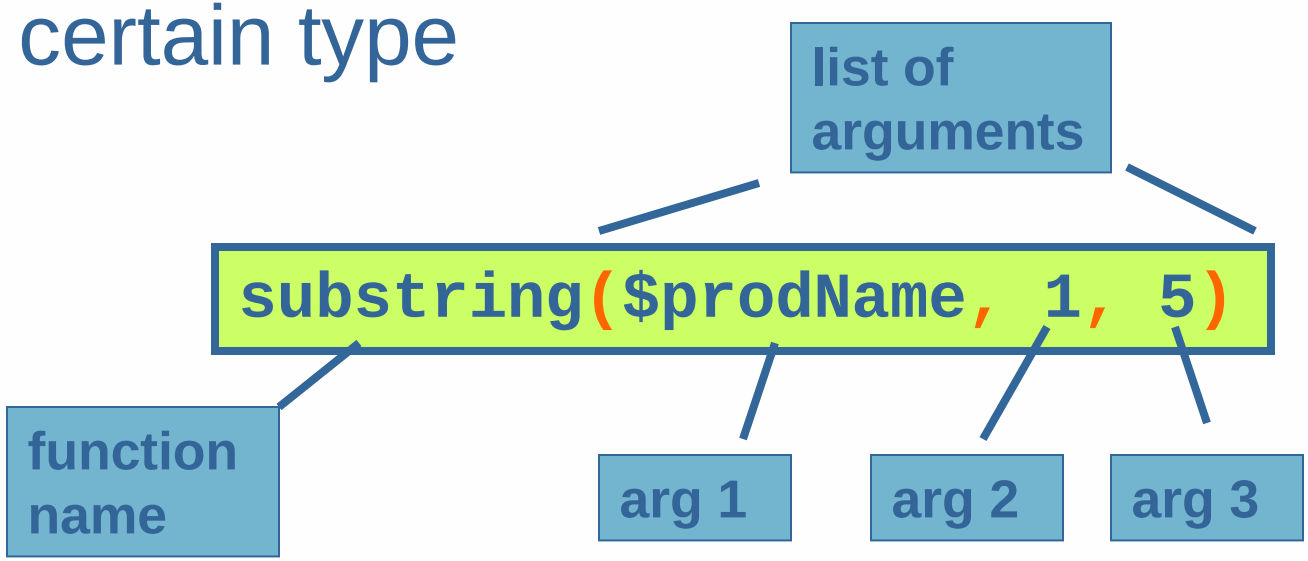
# More Built-In Functions

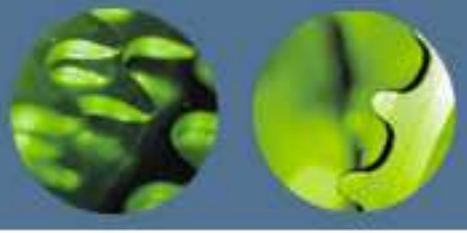
- Node-related
  - **`data, empty, exists, id, idref`**
- Name-related
  - **`local-name, in-scope-prefixes, QName, resolve-QName`**
- Error handling and trapping
  - **`error, trace, exactly-one`**
- Document- and URI-related
  - **`collection, doc, root, base-uri`**



# Function Calls

- An argument can be any single expression
  - e.g. a variable reference, a path expression
- An argument may be required to have a certain type





# Where Function Calls Appear

- Generally where any expression may appear, for example:
  - in a **`let`** clause

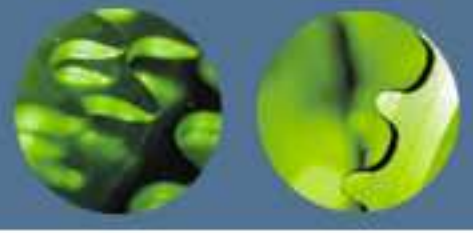
```
let $name := substring($prodName, 1, 5)
```

  - in a newly constructed element

```
<name>{substring($prodName, 1, 5)}</name>
```

  - in the predicate of a path expression

```
doc("cat.xml")/catalog/product
   [substring(name, 1, 3) = 'Ten']
```

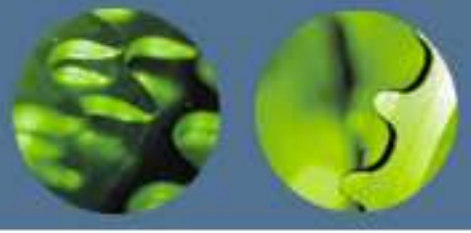


# Function Signatures

- Every function has one or more *signatures*
  - defines name, parameters and return type

```
substring($sourceString as xs:string?,
          $startingLoc as xs:double)
                                as xs:string
```

function name | parameter name | parameter type | return type

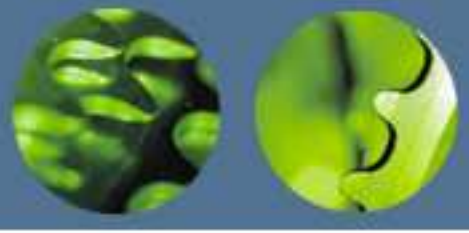


# Multiple Function Signatures

- Some functions have more than one signature
  - each signature must specify a different number of parameters

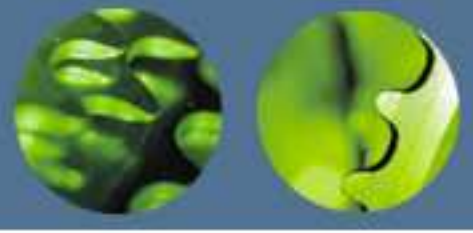
```
substring($sourceString as xs:string?,
          $startingLoc as xs:double)
    as xs:string
substring($sourceString as xs:string?,
          $startingLoc as xs:double,
          $length as xs:double)
    as xs:string
```

second signature has extra parameter



# Sequence Types

- Parameter types and return types are expressed as *sequence types*
- Most common are simple type names
  - e.g. **`xs:string`**, **`xs:integer`**, **`xs:double`**
  - argument must be an atomic value of that type
- Other sequence types:
  - **`item(), node(), element(), attribute()`**



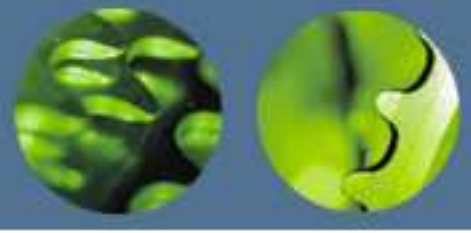
# Sequence Types and Occurrence Indicators

- Occurrence indicators indicate how many items are allowed:
  - ? for zero or one items
  - * for zero, one or many items
  - + for one or many items
  - *no indicator* for one and only one item

```
count($arg as item()*) as xs:integer
```

**argument can be zero, one or more items (atomic values or nodes)**

**return type is always a single integer**



# Argument Lists

- Must match the parameters in one of the function signatures in number and type

```
substring($prodName, 1, 5)
```

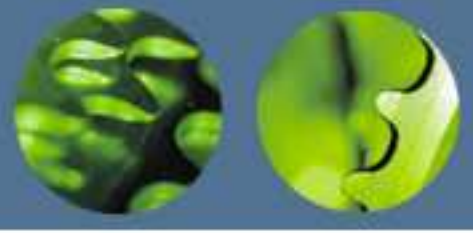
```
substring($prodName, 1)
```

~~`substring($prodName, 1, ())`~~

passing the empty sequence is not the same as omitting the argument

~~`substring($prodName, "1")`~~

type must match; string is not valid



# Argument Lists and Sequences

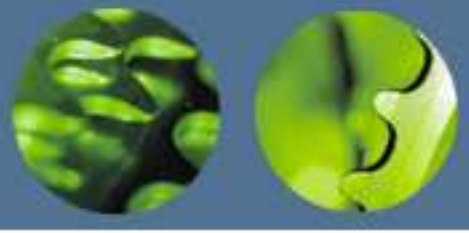
- Argument list syntax is similar to sequence construction syntax
  - do not confuse them

signature for `max`

```
max($arg as xs:anyAtomicType*)
  as xs:anyAtomicType?
```

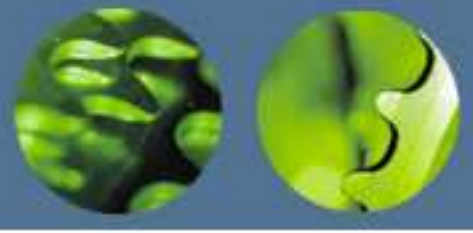
```
max( (1,2,3) )
```

~~`max(1,2,3)`~~



# Function Conversion Rules

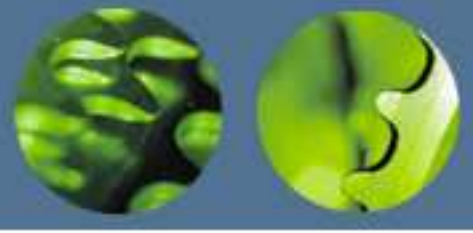
- Used when the type of an argument doesn't match the type in the signature
- Rules
  - Step 1: values are *atomized*
    - if it is expecting an atomic value and it receives a node
    - atomic value is automatically extracted from the node
  - Step 2: untyped values are cast
    - if it is expecting an integer and it receives an untyped value
  - Step 3: numeric values are promoted
    - if it is expecting a decimal and it receives an integer



# Function Conversion Rules Example

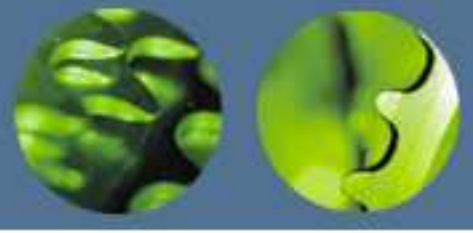
- If a function expects an argument of type **`xs:decimal?`** it accepts all of the following:
  - An atomic value of type **`xs:decimal`**
  - The empty sequence, because the occurrence indicator (?) allows for it
  - An atomic value of type **`xs:integer`**, because **`xs:integer`** is derived from **`xs:decimal`**
  - An untyped atomic value, whose value is 12.5, because it is cast to **`xs:decimal`** (Step 2)
  - An element node of type **`xs:decimal`**, because its value is extracted (Step 1)
  - An untyped element node whose content is 12.5, because its value is extracted (Step 1) and cast to **`xs:decimal`** (Step 2)
- It does not accept
  - an atomic value of type **`xs:string`**

# User-Defined Functions



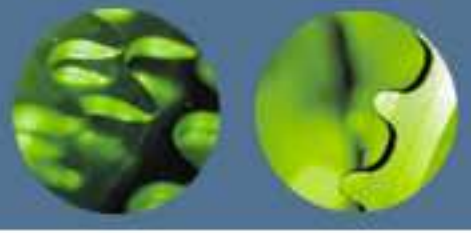
# Why Define Your Own Functions?

- Reuse
  - avoid writing the same expressions many times
    - simplifies the query
    - only needs to be maintained in one place
- Clarity
  - name and signature make it clear what is happening
- Recursion
  - almost impossible without functions
- Taking advantage of conversion rules
  - sometimes cleaner than explicit type casting, data extraction



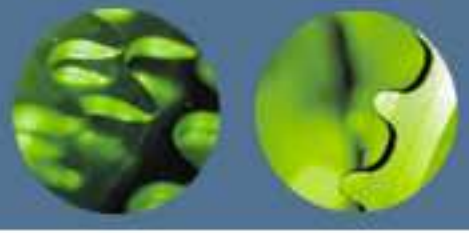
# Defining Your Own Functions

- Can be defined either
  - in the prolog;
  - in a separate module
- Use **`declare function`** keywords
  - followed by signature
  - followed by body of function in curly braces



# User-Defined Function Names

- Name must be:
  - a valid XML name
    - allowed characters are letters, digits, "_", "-", "."
    - must start with a letter or "_"
    - cannot start with **`xml`** (in upper or lower case)
    - case sensitive
  - prefixed with either:
    - a declared prefix, or
    - **`local`**
      - a namespace for use with user-defined functions



# User-Defined Function Example

function definition

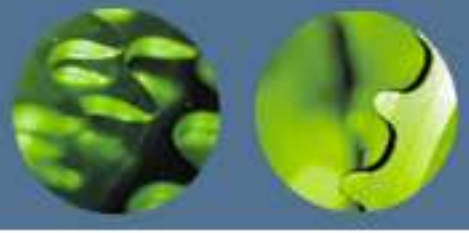
signature

```
declare function local:discountPrice(
                 $price as xs:decimal?,
                 $discount as xs:decimal?,
                 $maxDiscountPct as xs:integer?)
                 as xs:decimal?
{
   let $maxDiscount := ($price * $maxDiscountPct) div 100
   let $actualDiscount := (if ($maxDiscount lt $discount)
                           then $maxDiscount
                           else $discount)
   return ($price - $actualDiscount)
};
```

body

function call

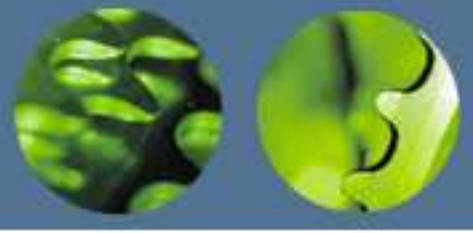
```
for $prod in doc("prc.xml")//prod
return
  local:discountPrice($prod/price, $prod/discount, 15)
```



# A Minimal User-Defined Function Example

```
declare function local:get-2()
{2}
```

- Any expression can be in the body
  - does not have to be a FLWOR expression
- Arguments are not required
- Return type is not required



# Functions and Variables

```
declare function local:discountPrice(
                 $price as xs:decimal?,
                 $discount as xs:decimal?,
                 $maxDiscountPct as xs:integer?)
                 as xs:decimal?
{
   let $maxDiscount := ($price * $maxDiscountPct) div 100
   let $actualDiscount := (if ($maxDiscount lt $discount)
                           then $maxDiscount
                           else $discount)
   return ($price - $actualDiscount)
};
```

function definition

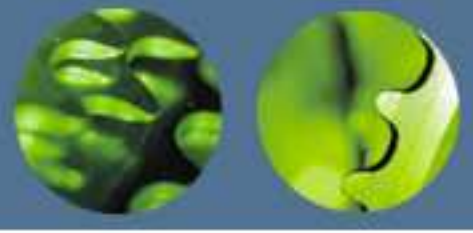
arguments are bound to variables

variables are referenced in body

```
for $prod in doc("prc.xml")//prod
return
  local:discountPrice($prod/price, $prod/discount, 15)
```

function call

$prod cannot be referenced in function body



# Functions and Context

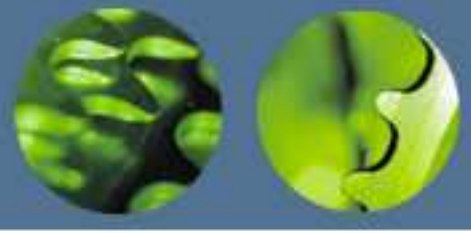
- Context *does not change* in function body

```
declare function local:prod2ndDigit() as xs:string? {
    substring(number, 2, 1)};

for $prod in (doc("cat.xml")//
  product[local:prod2ndDigit() > '5'])
return $prod
```

no context for number

```
declare function local:prod2ndDigit($prod as element()?)
  as xs:string? {
    substring($prod/number, 2, 1)};

for $product in (doc("cat.xml")//
  product[local:prod2ndDigit(.) > '5'])
return $product
```

context is passed as argument

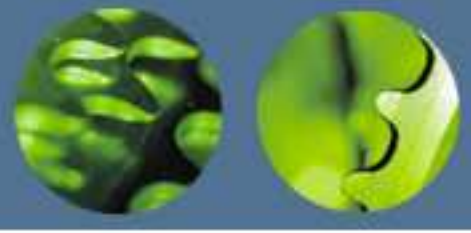


# Recursive Functions

- Functions can call themselves
- For example:
  - to count the number of descendants of an element

```
declare function local:numDescendants
  ($el as element()) as xs:integer {
    sum(for $child in $el/*
        return local:numDescendants($child) + 1)
};
```

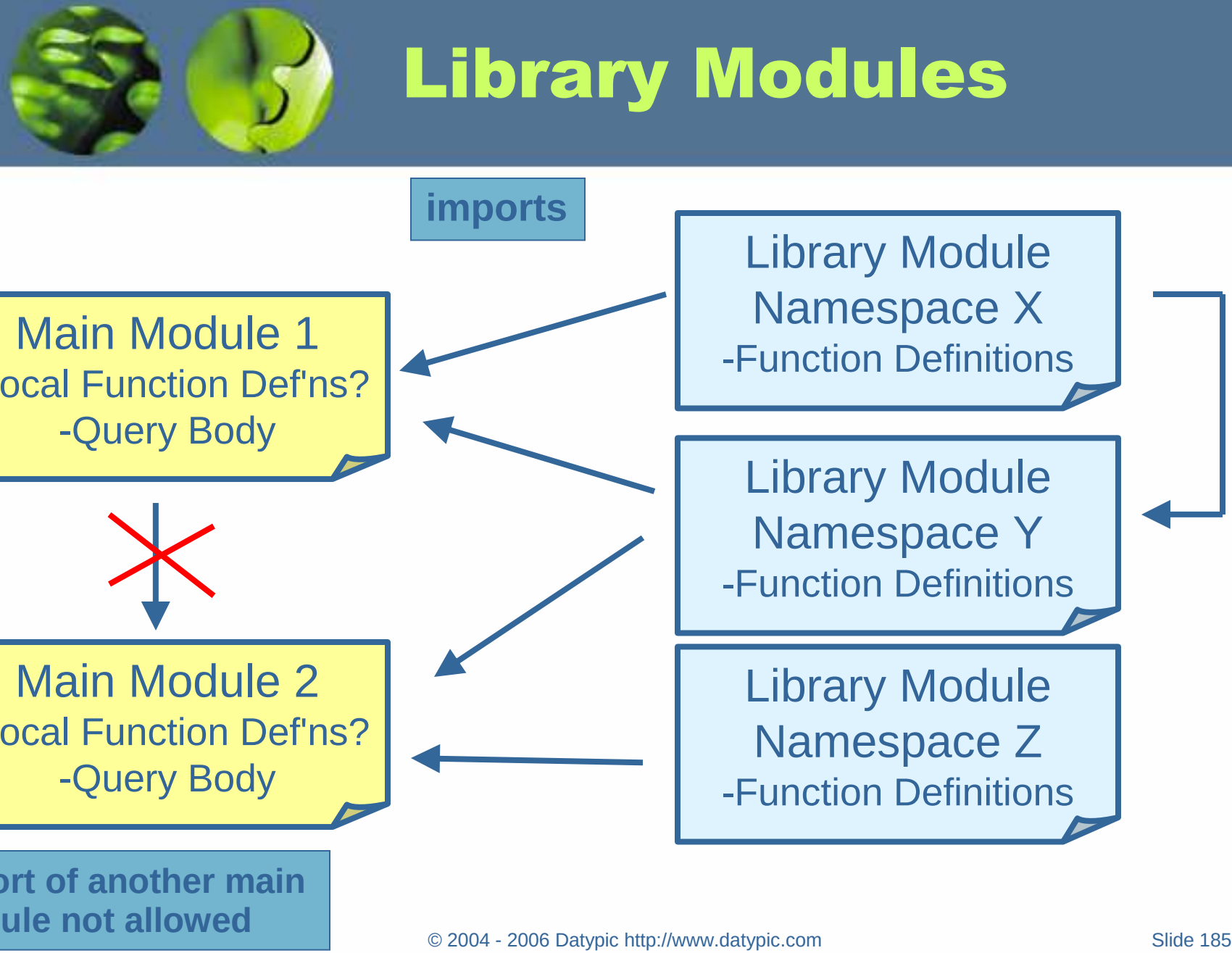
# Modules and Variables

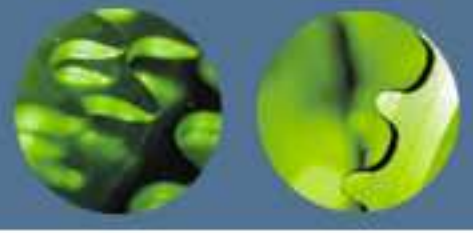


# Library Modules

- Separate XQuery documents that contain function definitions
- Why?
  - reusing functions among many queries
  - defining standardized libraries that can be distributed to a variety of query users
  - organizing and reducing the size of query modules

# Library Modules



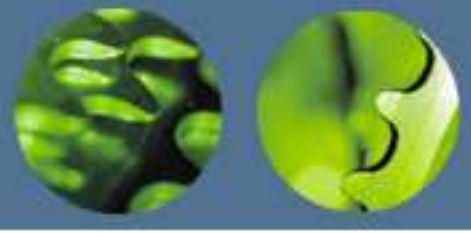


# Structure of Library Modules

- Start with a *module declaration*

```
module namespace x = "http://datypic.com/x";
```

- Have a target namespace that applies to all functions and variables declared in it
- Are all prolog; do not have a query body
- Can import other library modules



# Module Import Example

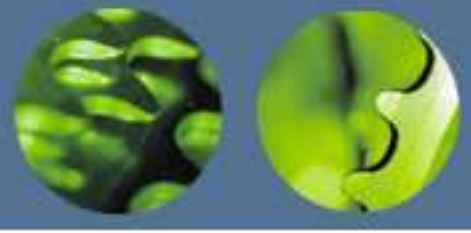
**main module**

```
import module
  namespace strings = "http://datypic.com/strings"
  at "http://datypic.com/strings/lib.xq";
-----------------------------------------------------
<results>strings:trim(doc("cat.xml")//name[1])</results>
```

target namespace

**library module**

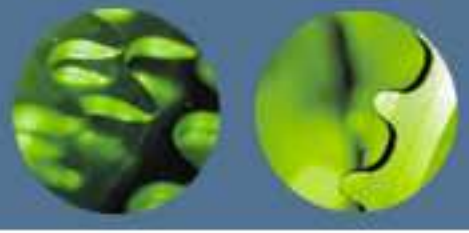
```
module namespace strings = "http://datypic.com/strings";
declare function strings:trim($arg as xs:string?)
  as xs:string? {
  (: ...function body here... :)
};
```



# Global Variables

- Declared and bound in the query prolog and used throughout the query

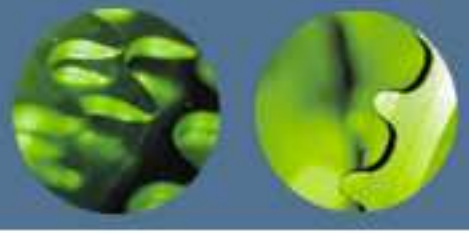
```
declare variable $maxNumItems := 3;
declare variable $ordDoc := doc("ord.xml");

for $item in
  $ordDoc//item[position() <= $maxNumItems]
return $item
```



# Global Variables

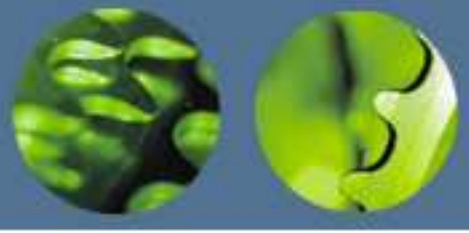
- Useful for:
  - constants
  - values that can be calculated up front and used throughout the query
- Can be:
  - referenced in a function that is declared in that module
  - referenced in other modules that import the module
  - bound (have a value set) by the processor outside the scope of the query

# A Closer Look at Types



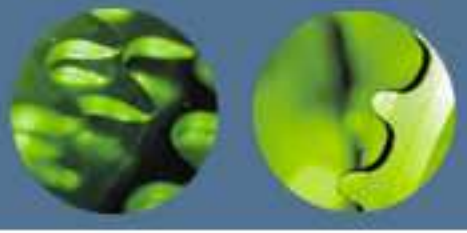
# The XQuery Type System

- Two kinds of types:
  - built-in types
    - simple types mostly based on XML Schema
  - imported types
    - simple and complex types defined by users in XML schemas



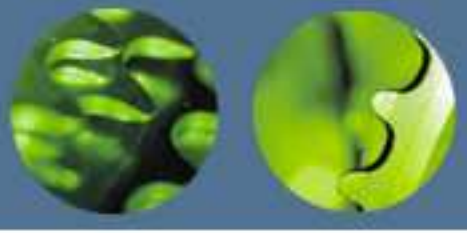
# 44 Types Built Into XML Schema

- String types
  - e.g. **`xs:string, xs:token, xs:language`**
- Numeric types
  - e.g. **`xs:integer, xs:decimal, xs:float`**
- Date and time types
  - e.g. **`xs:date, xs:time, xs:duration`**
- XML 1.0 types
  - e.g. **`xs:NMTOKEN, xs:ID, xs:ENTITY`**
- Others
  - e.g. **`xs:boolean, xs:anyURI, xs:QName`**



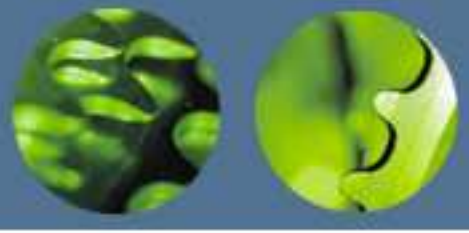
# 5 Types Added by XQuery/XPath

- Ordered duration types
  - **`xs:dayTimeDuration`**
  - **`xs:yearMonthDuration`**
- Untyped data (for XML data with no schema)
  - **`xs:untyped`**
  - **`xs:untypedAtomic`**
- Generic atomic type (for function signatures)
  - **`xs:anyAtomicType`**



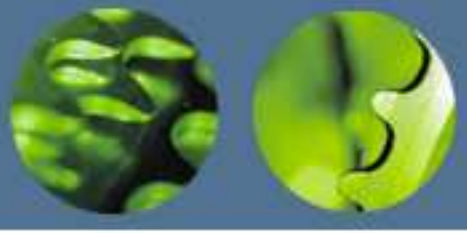
# Constructors and Casting

- Every atomic type has a corresponding *constructor* function
  - allows you to create values of that type
- For example, **`xs:date("2004-12-15")`**
    - creates an atomic value of type **`xs:date`**
- Argument can be an **`xs:string`**, and in some cases other types
  - for example, **`xs:float(12)`** creates an **`xs:float`** value from an **`xs:integer`** value



# XQuery is Strongly Typed

- Every expression evaluates to zero, one or more nodes or atomic values
- Every node and atomic value has a type
  - Elements & attributes have *type annotations*
  - Atomic values have *types*



# Expressions and Their Types

sequence of department element nodes

sequence of atomic string values

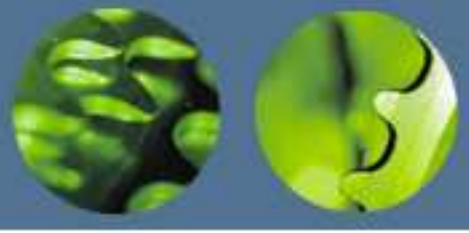
```
for $d in distinct-values(doc("ord.xml")//item/@dept)
let $items := doc("ord.xml")//item[@dept = $d]
order by $d
return <department name="{$d}"
                  totalQuantity="{sum($items/@quantity)}"/>
```

name attribute node

document node

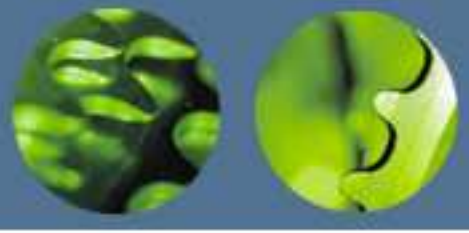
atomic integer value

atomic string value



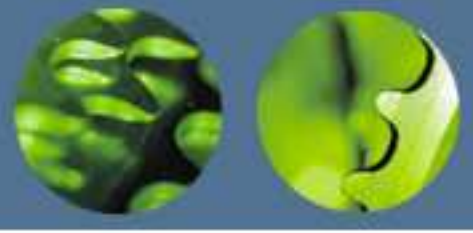
# Type Checking in XQuery

- Static analysis finds:
  - errors that do not depend on input data
    - syntax errors
    - referring to functions, variables or other names that are not declared
    - static type errors, e.g. **`"abc" + 3`**
- Dynamic analysis finds:
  - errors that are the result of data problems
    - e.g. **`sum(doc("cat.xml")//number)`** raises an error if a **`number`** does not contain valid numeric data



# Strong Typing: Pros and Cons

- Pro
  - easy identification of static errors
    - saves time debugging and testing
    - identifies errors that even testing may not ever uncover
- Con
  - adds complexity because explicit casting is required in some cases



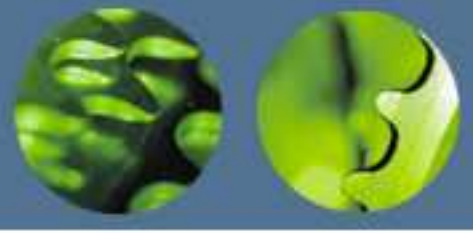
# Do I Have to Pay Attention to Types?

- Usually, no, not if you don't want to.
  - without a schema, your XML data is "untyped"
    - it has one of the "untyped" types:
      - **`xs:untyped`** for elements,
      - **`xs:untypedAtomic`** for attributes and atomic values
  - in most expressions, untyped values are cast to the expected types

```
product/number + 23
```

```
sum(product/number)
```

**if `number` is untyped, it is cast to a numeric type automatically**



# When You Have to Pay Attention to Types

- use **`number`** and **`string`** functions (or type constructors) to cast between types

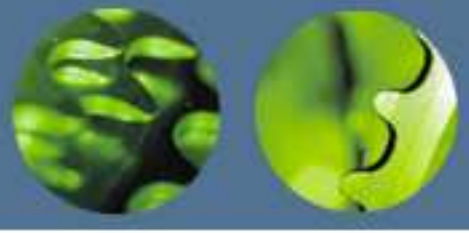
```
let $date := current-date()
return <year>{
 substring(string($date),1,4)
}</year>
```

without `string` function, it's a type error because the `substring` function is expecting `xs:string` values only; `$date` is an `xs:date`.

```
for $prod in doc("cat.xml")//product
order by number($prod/number)
return $prod/name
```

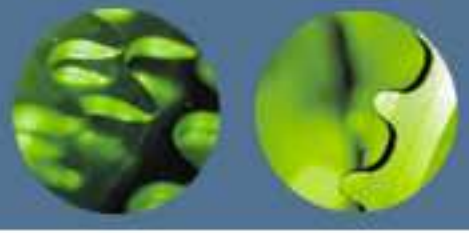
without `number` function, 53 will be sorted after 144

# Schemas



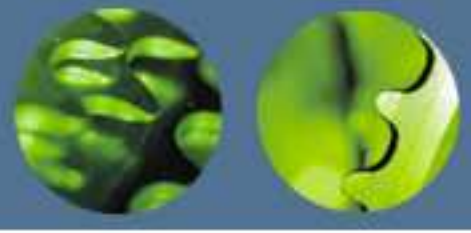
# What's a Schema?

- Describes the structure and data content of an XML document
- Can be used to validate XML documents
  - input documents or result documents
- Can be used to pass information to the query about types



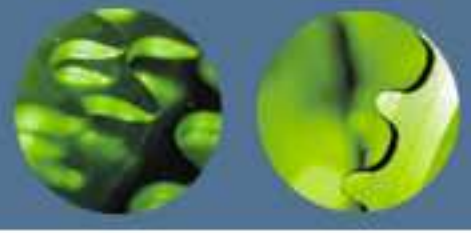
# Schema Example

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
   targetNamespace="http://datypic.com/prod.xsd"
   elementFormDefault="qualified">
  <xs:element name="product" type="ProductType"/>
  <xs:complexType name="ProductType">
    <xs:sequence>
      <xs:element name="number" type="xs:integer"/>
      <xs:element name="name" type="NameType"/>
    </xs:sequence>
    <xs:attribute name="dept" type="xs:string"/>
  </xs:complexType>
  <xs:complex name="NameType">
    <xs:simpleContent>
      <xs:extension base="xs:string">
        <xs:attribute name="language" type="xs:string"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:simpleType></xs:schema>
```



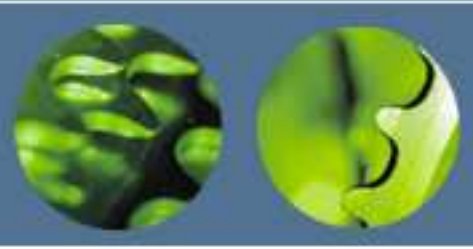
# Benefits of Using Schemas

- Predictability of input documents
  - no need to use if-thens to check input data before processing
- Better identification of static errors
  - allows discovery of errors in the query that were not otherwise apparent
- Validity of query results
  - provides guarantee that a query will produce results that always conform to, for example, XHTML
- Special processing based on type
  - you could write an expression that processes the address element differently depending on whether it is of type USAddressType, UKAddressType, etc.



# Schemas and XQuery

- Use of schemas is *optional*
- Some processors may:
  - validate documents when they are accessed e.g. using the **doc** function
    - or even outside the scope of the query
  - allow you to import schema documents
  - allow you to explicitly validate input or result documents using these imported definitions



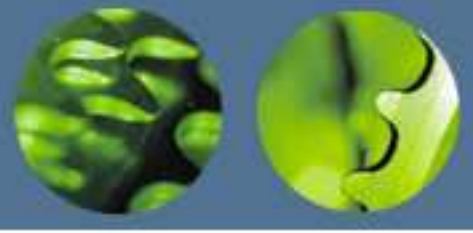
# Using Schemas to Catch Static Errors

```
import schema
  default element namespace
    "http://datypic.com/prod"
  at "http://datypic.com/prod.xsd";

for $prod in doc("cat.xml")/produt
order by $prod/product/number
return $prod/name + 1
```

misspelling

invalid path; `product` will never have `product` child

type error: `name` is declared to be of type `xs:string`, so cannot be used in an add operation



# Using Schemas to Validate Results

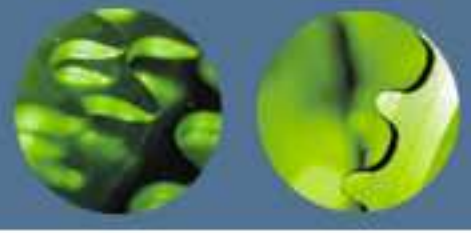
```
import schema
  default element namespace
    "http://datypic.com/prod"
  at "http://datypic.com/prod.xsd";

validate {
<product dept="ACC" xmlns="http://datypic.com/prod">
  <number>563</number>
  <name language="en">Ten-Gallon Hat</name>
</product> }
```

target namespace

schema location

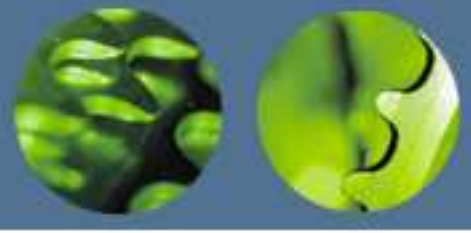
explicit validation

# Resources



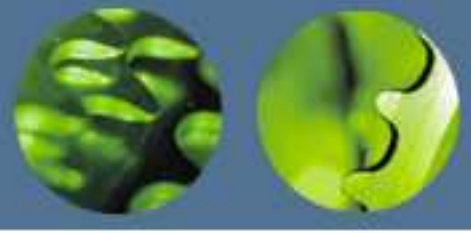
# W3C Recommendations

- Many documents; varying degrees of readability
- The most useful are:
  - XQuery 1.0: An XML Query Language
    - the basic syntax of XQuery
  - XQuery 1.0 and XPath 2.0 Functions and Operators
    - the built-in functions
  - XML Query Use Cases
    - good examples of queries for specific uses
- See **`http://www.w3.org/XML/Query#specs`** for links to all the recommendations



# Books

- Kay, Michael. *XPath 2.0 Programmer's Reference*. Wrox, 2004.
  - a great reference for where XQuery overlaps with XPath
- Katz, Howard et. al. *XQuery from the Experts.* Addison-Wesley, 2003.
  - very interesting for implementers, or those who want to understand the design of the language on a deeper level
- Walmsley, Priscilla, *XQuery.* O'Reilly, 2006.
  - intended as both a tutorial and a reference; XQuery made easy!



# Other Resources

- Mailing lists
  - talk@xquery.com
    - practical discussion about XQuery
  - www-ql@w3.org
    - for general discussion on query languages
- Examples
  - www.xqueryfunctions.com
    - over 100 examples of useful XQuery functions

# Thank You