

The Creation of Multiple Standards with Common Data-Types

Robert C. Leif

Newport Instruments, San Diego, CA. rleif@rleif.com, www.newportinstruments.com

Introduction

The process of creation of cytology-pathology standards-specifications that can interoperate has been greatly confounded by the differences in the requirements, needs, and past histories of the creating organizations. Since the differences between the software models of a digital microscope and a flow cytometer are minimal, it is reasonable to apply a common data standard to these 2 modalities. Except for DICOM and the Flow Cytometry Standard (FCS), these efforts are all based on XML languages: XML Schema Design Language, (XSDL) and XML Resource Description Framework (RDF). Present efforts include:

Specification

The abbreviation of the XML languages is given in parentheses below

- The Laboratory Digital Imaging Project, LDIP, Data Exchange Specification (RDF) <http://www.ldip.org>

Standards

- DICOM Working Group 26, WG 26, <http://medical.nema.org/>
- International Society for Analytical Cytometry, ISAC, Data File Standard for Flow Cytometry, FCS, <http://www.isac-net.org>
- Health Level 7, HL 7, (XSDL), <http://www.hl7.org>
- Open Microscopy Environment, OME, (XSDL) <http://www.openmicroscopy.org>
- Flowcyt (XSDL & RDF), <http://www.flowcyt.org>
- Cytometry Markup language, CytometryML, (XSDL), <http://www.newportinstruments.comcytometrymlcytometryml.htm>

Interests

- Pathology images: LDIP and DICOM WG 26
- Measurements on large numbers of individual cells generated from flow and image cytometry: Standards created by members of the International Society for Analytical Society (ISAC).
- LDIP's interest is in "developing a set of definitions to clarify the uses of imaging in pathology and laboratory medicine."
- ISAC and OME share a common interest in the transfer of data.
- DICOM Working Group 26 plans to evaluate and extend the current DICOM standard as it relates to newer microscopic techniques including whole slide imaging.
- CytometryML is creating a detailed description of the the datatypes and data structures necessary to repeat a cyto- or histochemical measurement.

Data Exchange: Since DICOM was created prior to XML, DICOM has been extended (Part 18: Web Access to DICOM Persistent Objects (WADO)). The problem of data exchange between the standards has been exacerbated by the inability of the XML ontology languages (RDF and OWL) to directly reference and thus reuse XSDL schema complexTypes (classes).

XSDL Schemas Vs. Resource Description Framework (RDF)

- The purpose of CytometryML schemas is to precisely specify data types that can be used to facilitate the transfer, storage, presentation, and creation of data, while minimizing the probability of mistakes that can occur during these processes. These uses include:
 - 1) Precisely describing in detail objects, such as: images, parts of a microscope, slides, staining, and binary data that describes individual cells.
 - 2) Assisting in the design and creation of databases.
 - 3) Providing data in a form suitable for reports and forms.
- The purpose of the RDF undertakings, LDIP and the Flowcyt FaceOntology, is to document relations between data and to provide flexibility in describing data.
- In short, CytometryML consists of nouns and their associated adjectives and RDF consists of simple sentences consisting of a subject predicate and an object.
- Unfortunately at present, the RDF parsers, where information is available, lack the capacity to work with elements or datatypes from XML schema. However, it appears that such a linkage is possible via id attributes that are included in XML schema simpleTypes. Provision for this is being included in CytometryML.

Problem

- "The nice thing about standards is that there are so many to choose from." –Andrew S. Tannenbaum
- "Standards have become so popular that every society wants to make one for themselves." -anon

Partial Solution Based on Reuse

- Reuse is a well known software engineering practice, which besides being applied to code, has been applied to many other parts of the development environment, such as designs, documentation, and tests.
- Standards paucity, the practice of reusing datatypes and their documentation from other standards, is an extension of reuse methodology to standards. This reuse minimizes the design effort, facilitates interoperability, and maximizes the reliability of the CytometryML schemas due to the previous successful use of many of the data-types in implementations of DICOM and FCS.
- Although the different groups employ different representations (syntax) for their data, the definitions (semantics) of the data-types should, as much as possible, be common to all of the standards.
- The achievement of interoperability should be facilitated by employing data-types with common semantics and limiting the difference between standards-specifications to syntax.
- The extension of DICOM by Working Group 26 will result in the significant benefit of having one set of semantics and terms for medical imaging that is used throughout the medical profession and by scientists engaged in Cytometry.
- CytometryML is an attempt to create a pilot implementation in XSDL of part of the designs developed by Working Group 26.
- The creation of new data-types was facilitated by extending and/or enhancing already existing data-types.

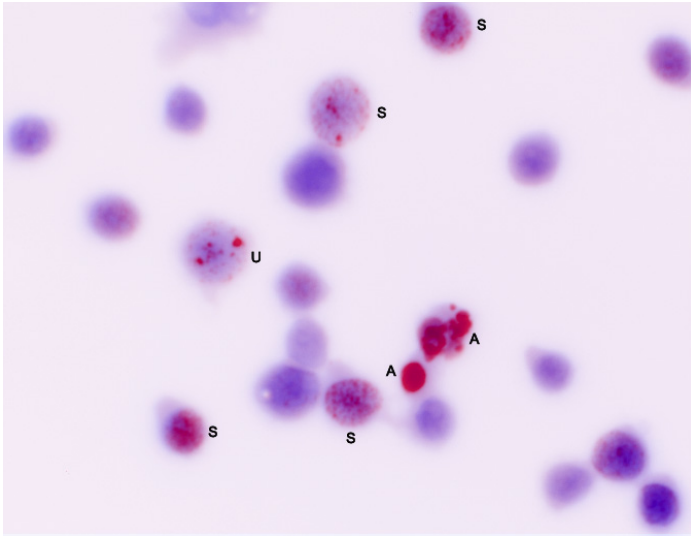
CytometryML General Requirements

- 1) The CytometryML schemas will describe the datatypes necessary to repeat a cyto- or histochemical measurement.
- 2) Both Imaging and Flow Cytometry data should be described in the same standard.
- 3) The datatypes in these schemas, wherever reasonable, will be derived from DICOM and FCS.
- 4) Interconvertibility between CytometryML and pre-existing standards will be maximized.
- 5) Software engineering principles will be adhered to, which should facilitate acceptance by the FDA and other regulatory bodies of software that includes CytometryML components.

METHODS

1. A requirements document and a hazard analysis were published to acquire appropriate peer review.
2. Data-types were reused from DICOM, FCS, and numerical types were reused from Ecma-International (<http://www.ecma-international.org/>).
3. The CytometryML schemas were developed using XSDL and were validated with both StylusStudio and XMLSpy. These schemas are primarily derived from DICOM data-types with XSDL documentation elements that included references to the descriptions of the data-types in the DICOM standard and data-types that could be part of an extension of DICOM data-types.
4. An image schema was created, which is based on data-types imported from multiple schemas. An image complex-Type, which consisted of multiple element datatype pairs and an element based on that datatype were created and validated.
5. XMLSpy was used to produce an example XML file (document) from the image element in the image schema. This image.xml page was then filled in with values and validated with XMLSpy.
6. A use case was created by filling the image.xml document with data from an existing image and the XML was validated against the image schema.
7. Visual inspection of the XML document was used to detect design defects including the order of the elements. The appropriate schema was corrected and the process was iterated. This process was first described by Boehm; and he named it, the spiral model of development.

Image that provided the data for the XML Document



Digital image of tissue culture cells, which had been cultured in the presence of 5BrdUrd. The red emission is from anti-5BrdU labeled with EuMac. The blue emission is from DAPI. Both the blue and the red images were obtained with a 60 x oil immersion lens and continuous excitation at 365 nm. The DNA synthesizing cells (S) have a punctuate staining pattern, which shows the small islands of DNA synthesis. The apoptotic cells (A) have large and densely stained areas, which are the result of strand breakage induced by apoptosis. The unknown (U) cell has a staining pattern that contains features of both S phase and apoptosis.

This image has been processed to look like an absorbance image.

Brief Description of XML Syntax

An XML document that describes an image has been generated from the Image schema. The actual XML at the beginning of the XML document is shown below and is color coded. XML and the other XML languages are nested languages. The document below starts with items that describe the image in general. The **numbers** are not part of the XML document.

1 `<Acquisition_Date_Time VR="DT" Tag="0008,002A">2006-07-17T09:30:47.0Z</Acquisition_Date_Time>`
 Element 1. (E1) `Acquisition_Date_Time` is the first element. It starts with a `<` character and contains two attributes, the DICOM **VR** and **Tag**. These **attributes** are separated from their **values** by an `=` character. The first part of the element is closed by a `>`. The value (17 July, 2006, 9:30 AM 30.47 seconds, (Coordinated Universal Time, UTC or GMT) of the element, the DICOM date and time is shown between the first and second part of the element.

The second part of the element starts with a `</` and ends with a `>`. Since these attribute values have been coded as constants in the schema, these have only been shown in the first **element**. However, for an XML page that is based on CytometryML schemas to interact with DICOM, the **Tag** specifies the specific DICOM datatype and the Value Representation, **VR**, specifies the general class, which indicates how the object should be processed and serves as a check on the validity of the **Tag**. The inclusion of the **Tag** attribute for each DICOM data item requires that the **element** be based on an XSDL complexType, which presently cannot be used by RDF.

2 `<File_Location>http://www.newportinstruments.com/quantum/image/apoptosis.jpg</File_Location>`

E2 shows the URL of the file and thus serves to connect the file with the description of its contents and by its extension, jpg, to its file type JPEG.

3 `<General_Image>`

4 `<Originality>Original</Originality>`

E3 is a nested structure (General_Image) that provides information whether the data (E4) was directly produced by the camera (Original) or was the result of a computer program (Derived).

5 `<Examination_Characteristic>Primary</Examination_Characteristic>`

`</General_Image>`

E5 describes if the image is the direct result of the primary examination or a subsequently obtained, secondary image.

6 `<Rows>518</Rows>`

7 `<Columns>680</Columns>`

E6 and E7 describe respectively the number of rows and columns in the image.

Other items that are based on the image schema

The rest of the items that complete the description of the image follow the order of the complete XML document and are described as text. The CytometryML schemas and XML documents are available at <http://www.newportinstruments.com/cytometryml/cytometryml.htm>

- The X and Y slide coordinates of the image center,
- whether it is compressed and if so, was the compression lossy or lossless, the type of compression, and the compression ratio.

- The Planar Configuration indicates whether the pixel stores the data as multiple monochrome layers color-by-plane or as one layer with the pixel being a vector, color-by-pixel. For measurements that include channels (parameters) other colors or more than 3 colors, these two choices also refer to the channels.

Items describing specific classes (schemas) present in the image

Pixels

- A list of the channels (parameters or colors);
- The number of channels contained in the pixel;
- The Aspect Ratio of the pixel, which specifies the ratio of the vertical (Y) and horizontal (X) sizes.
- The Photometric Interpretation is an enumeration of the pixels' content that includes: Monochrome, RGB, others specific to DICOM. The suggested addition of Multi-Spectral will increase the number of measurements per pixel beyond 3.

Pixel's channels

- Each channel has both a Short and Long Name
- The description of each channel includes:
 - the analyte binding species (STAIN, IgG, DNA etc.), analyte's name, and chemistry;
 - the label's name (Fluorescein, Cy5, Peroxidase, etc.) and chemistry;
 - the excitation source (Arc, LED, laser) including its filter;
 - the measurement (absorbance, fluorescence, polarization, etc.) the detector (CCD, PMT, array, etc.), and its optics (beam splitter (dichroic mirror), filter, spectrograph, etc.);
 - the amplifier, transform (linear, log) and the data-type of the channel (parameter). At least one and up to 50 channels can be included.

Slide

- Material and transparency;
- Dimensions, maximum values of X, Y, and Z (optional) of the slide;
- Number;
- Reference and specimen areas;
- Mounting medium;
- Coverslip
- Dimensions, maximum values of X and Y, as well as minimum and maximum values for the thickness (Z).

Microscope

- Capacity for sorting or isolating single cells);
- Platform (stand) direction (upright or inverted);
- List of objectives;
- Objective used
 - Name
 - Correction levels: chromatic and field flatness;
 - Air or oil;
 - Magnification;
 - N.A.
 - Working distance;
 - Contrast method including none;
 - High and low transmittance cut offs.
- Condenser used
 - Name;
 - Correction levels: chromatic and field flatness;
 - Air or oil;
 - N.A;
 - Contrast method including none.
- An optional comment, equivalent to a DICOM long string.

General Information Schema

- For items that can be purchased, the following information can be included:
 - Manufacturer
 - Model name and number

- Serial number
- Web address of the manufacturer.

Objective Example

Hopefully in the future, much of the constant information described above will be supplied by the manufacturer as an XML file, such as the one below, which describes the objective employed for the image above.

```
<Objective Chromat="Semi-Apochromat" id="Oil60x" Immersion="Oil" Magnification="60" Field_Flatness="Plan"
Contrast="None" Name="Oil60x" Function="Objective" NA="1.25">
  <optics:Cut_Offs High_Cut_Off="1000" Low_Cut_Off="350" Band_Width_Location="1/2 height"/>
  <optics:Working_Distance Prefix_Case_Sen="μ" Si_Unit_Name="meter" Value="120"/>
  <optics:Item_General_Info>
    <item:Manufacturer>Olympus
  </item:Manufacturer>
    <item:Model_Name>UPLFN
  </item:Model_Name>
    <item:Model_Number>60XOI
  </item:Model_Number>
    <item:Item_Serial_number>Unavailable
  </item:Item_Serial_number>
    <item:URI_Var>http://www.olympusamerica.com
  </item:URI_Var>
  </optics:Item_General_Info></Objective>
```

In most cases, as is shown in the case of the Working_Distance, the units have been included.

Meta Information and the Dublin Core

- Meta information concerning each schema is stored in the schema. This information is described in the Configuration schema. The Configuration schema contains a ComplexType that has been used to generate the meta information part of an XML document. This meta information is loosely based on that present in the Dublin Core (<http://dublincore.org>).
- Major differences from the Dublin Core included in configuration schema are
 - 1) the replacement of the author by the name and E-mail address of the person responsible for maintaining the software. This should facilitate assistance when the inevitable problems arise.
 - 2) Since this software may eventually be used in medical devices, it also includes the regulatory status.
 - 3) Configuration.xsd can be imported into other schemas to provide elements that can serve as a header and can be used to generate the necessary metadata in an XML or XHTML page or facilitate the entry of this data into an XForm.

A Single Standard for both Digital Imaging and Flow Analysis

- Both flow cytometers and digital microscopes can produce each other's type of data. The Amnis[®] ImageStream (<http://www.amnis.com/>), which is a flow cytometer, produces images and the CompuCyte iColor[™] Fluoro-Chromatic Imaging Cytometer (<http://www.compucyte.com/>), which is a laser scanning microscope, produces Flow Cytometry Standard list-mode (arrays of data produced by individual cells) files. Flow cytometry software is often employed to analyze list mode data obtained with other digital microscopes.
- The Microscope and Flow Cytometer datatypes in CytometryML were both derived from a generic cytometer datatype.
- Since both instruments can be epi-illuminated for fluorescence, the minimum number of condensers is zero
- The 3 differences between the datatypes are shown in the table below.
 - Since XSDL permits limiting values of types to specific ranges, reasonable maxima have been included. In the future, if warranted, these can be easily changed. The inclusion of assertions describing maxima and minima helps prevent data corruption and facilitates the detection of errors.

Differences between the Microscope and Flow Cytometer ComplexTypes

| Name | Microscope Type | Flow Type |
|---------------------|-----------------|-----------|
| Objective MaxOccurs | 7 | 1 |
| Condenser MaxOccurs | 1 | 10 |
| Carrier | Solid | Fluid |

- A flow cytometer has a single objective. A reasonable maximum value for the number of objectives that can be attached to a nosepiece is 7.

- A microscope can have only one condenser; each of the light sources of a flow cytometer requires its own condenser. Ten is a reasonable maximum value for the number of light sources that can be used in a flow cytometer.
- Objects on a solid support, slide, are imaged by microscopes; cells and particles in a flowing fluid are measured and/or imaged by flow cytometers.

Results

- The creation of a collection of XML schemas, CytometryML, has demonstrated the feasibility of reusing the semantics of data-types from DICOM and those from ISAC's FCS standard, as well as reusing their documentation.
- CytometryML has been used to rapidly prototype a WG 26 design.
- The inclusion of constant attributes to link CytometryML to the DICOM standard and the legacy Flow Cytometry Standard (FCS) has been done.
- However this inclusion results in a small but acceptable increase in complexity of the code, the use of XSDL complexTypes.
- Unfortunately, it does not appear that there is any standard means to link a complexType to RTF.
- The essential unity of flow cytometers and digital microscopes has been demonstrated by deriving both data-types from a common cytometer data-type.

Conclusions

- In situations where multiple standards are being created, interoperability can be facilitated by employing data-types based on a common set of semantics.
- Reuse of DICOM types and reuse of their descriptions in the XML schemas minimized the design effort, will maximize reliability and interoperability, can facilitate the design of new DICOM datatypes, and hopefully will improve the linkage between DICOM and XML.
- CytometryML should be extended to include many of the new DICOM data-types that describe patients, specimens, etc. being prepared by DICOM WG 26 and by LDIP.
- The XML page produced by this project will hopefully assist the members of WG 26 in the determination of the eventual content of the proposed supplement.
- Since Flow cytometers and digital microscopes are sufficiently similar that they can be derived from a common ancestor, a generic cytometer; there is no need to have a separate standard for each modality.
- If the problem of the incompatibility of RDF and XML schema can be solved, the combination would be worth much more than the sum of the individual parts.

ACKNOWLEDGMENTS

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Financial Disclosure

Newport instruments is owned by Robert C. Leif, Ph.D and his partners. Our plan is to offer royalty free licenses to scientific and medical societies provided that they either both charge a reasonable amount to sublicense the schemas and take over the responsibility for its maintenance; or the society sublicensed the schemas for free with the proviso that the sublicense did not include the GNU poison pill, prohibition on software patents, or other similar commercial limitations.

Copies of the XML files described above and the schemas used to generate it are available at <http://www.newportinstruments.com/cytometryml/cytometryml.htm>

Suggested Reading

1. B. Boehm, K. Sullivan, "Software Economics: A Roadmap", International Conference on Software Engineering, Proceedings of the Conference on The Future of Software Engineering, ACM Press New York, NY, USA. (2000).
2. Nancy G. Leveson, "SAFEWARE: System Safety and Computers", Addison-Wesley, ISBN: 0-201-11972-2. (1995).
3. Nancy G. Leveson, "System Safety Engineering: Back To The Future", <http://sunnyday.mit.edu/book2.pdf> (2002)
4. Pricilla Warmsley, Definitive XML Schema, Prentice Hall, www.phptr.com (2002).
5. Frank Manola, Eric Miller (Editors), "RDF Primer, W3C Recommendation 10 February 2004, <http://www.w3.org/TR/rdf-primer/>

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <!--Sample XML file generated by XMLSpy v2006 rel. 3 U (http://www.altova.com)-->
3 <image:image xmlns:image="http://CytometryML/Schemas/image"
4 xmlns:arrays="http://CytometryML/Schemas/arrays"
5 xmlns:channels="http://CytometryML/Schemas/channels"
6 xmlns:data="http://CytometryML/Schemas/data"
7 xmlns:config="http://CytometryML/Schemas/XML_Uilities/configuration"
8 xmlns:detectors="http://CytometryML/Schemas/detectors"
9 xmlns:dicom="http://CytometryML/Schemas/dicom"
10 xmlns:excite="http://CytometryML/Schemas/excitation"
11 xmlns:fcs="http://CytometryML/Schemas/fcs_3_0"
12 xmlns:filters="http://CytometryML/Schemas/filters"
13 xmlns:instr="http://CytometryML/Schemas/instrument"
14 xmlns:item="http://CytometryML/Schemas/item"
15 xmlns:multi="http://CytometryML/Schemas/multiplex_groups"
16 xmlns:num_data="http://CytometryML/Schemas/num_data"
17 xmlns:nums="http://CytometryML/Schemas/XML_Uilities/num_types"
18 xmlns:optics="http://CytometryML/Schemas/optics"
19 xmlns:pn="http://CytometryML/Schemas/person_name"
20 xmlns:pixel="http://CytometryML/Schemas/pixel"
21 xmlns:slide="http://CytometryML/Schemas/slide"
22 xmlns:stains="http://CytometryML/Schemas/stains"
23 xmlns:trans="http://www.CytometryML/Schemas/trans_media"
24 xmlns:time="http://CytometryML/Schemas/time"
25 xmlns:ucum="http://CytometryML/Schemas/ucum"
26 xmlns:units="http://CytometryML/Schemas/units"
27 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
28 xsi:schemaLocation="http://CytometryML/Schemas/image
29 G:\CytometryML\Schemas\image.xsd">
30 <Acquisition_Date_Time VR="DT" Tag="0008,002A">2006-07-17T09:30:47.0Z</Acquisition_Date_Time>
31 <File_Location>
32 http://www.newportinstruments.com/quantum/image/apoptosis.jpg</File_Location>
33 <General_Image>
34 <Originality>Derived</Originality>
35 <Examination_Characteristic>Primary</Examination_Characteristic>
36 </General_Image>
37 <Rows>518</Rows>
38 <Columns>680</Columns>
39 <Center_Point_Coordinate>
40 <slide:X_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="2.340"/>
41 <slide:Y_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="1.255"/>
42 </Center_Point_Coordinate>
43 <Compression>
44 <Lossy_Image_Compression>
45 <Lossy_Image_Compression_Ratio>10.0</Lossy_Image_Compression_Ratio>
46 <Lossy_Image_Compression_Method>JPEG_Lossy</Lossy_Image_Compression_Method>
47 </Lossy_Image_Compression>
48 </Compression>
49 <Planar_Configuration>
50 color-by-pixel
51 </Planar_Configuration>
52 <Pixels channels:Channels_List="EuMac-Anti5BrdU">
53 <Pixel_Aspect_Ratio>1.0</Pixel_Aspect_Ratio>
54 <Samples_Per_Pixel>2</Samples_Per_Pixel>
55 <Photometric_Interpretation>
56 <Mode>Multi-Spectral</Mode>
57 </Photometric_Interpretation>
58 <Channels id="EuMac-Anti5BrdU">
59 <channels:Waveform_Channel_Number>2</channels:Waveform_Channel_Number>
60 <channels:Short_Name>EuMac-Anti5BrdU</channels:Short_Name>
61 <channels:Long_Name>EuMac-Anti5BrdU labeled S phase cells</channels:Long_Name>

```

```

62 <channels:Reagent_Info>
63   <stains:Binding_Species>IgG</stains:Binding_Species>
64   <stains:Binding_Species_Name>Anti-5BrdU</stains:Binding_Species_Name>
65   <stains:Label>
66     <stains:Label_Name>Eu Quantum Dye</stains:Label_Name>
67     <stains:Label_Abbreviation>EuMac</stains:Label_Abbreviation>
68     <stains:Reactive_Functionality Reactive_Functionality_Num="mono">
69       <stains:Reactive_Functionality_Name>Isothiocyanate</stains:Reactive_Functionality_Name>
70     </stains:Reactive_Functionality>
71   </stains:Label>
72   <stains:Reagent_Formula_Wt>674</stains:Reagent_Formula_Wt>
73   <stains:Item_General_Info>
74     <item:Manufacturer>Newport Instruments</item:Manufacturer>
75     <item:Model_Name>EuMac-Anti-5BrdU</item:Model_Name>
76     <item:Item_Lot-number>1</item:Item_Lot-number>
77     <item:URI_Var>http://www.newportinstruments.com</item:URI_Var>
78   </stains:Item_General_Info>
79   <stains:Comment>Collaborative effort by Lidia M. Vallarino et al. and Robert C. Leif et al.</
stains:Comment>
80 </channels:Reagent_Info>
81 <channels:Dectector_Info>
82   <detectors:Detector FCS_Keyword="$PnT">CCD_Camera</detectors:Detector>
83   <detectors:Detector_Setting>3.14159E0</detectors:Detector_Setting>
84   <detectors:Detector_Units>
85     <units:Scientific_Unit Prefix_Case_Sen="" Si_Unit_Name="second" Value="6.0"/>
86   </detectors:Detector_Units>
87   <detectors:Measurement>Fluorescence</detectors:Measurement>
88   <detectors:Beam_Splitter_Info Unit="meter" Prefix="nano">
89     <Dichroic_Mirror Pass="High">
90       <Dichroic_Mirror_Range>
91         <Fifty_Percent_On>400</Fifty_Percent_On>
92         <Fifty_Percent_Off>400</Fifty_Percent_Off>
93       </Dichroic_Mirror_Range>
94     </Dichroic_Mirror>
95     <Item_General_Info>
96       <item:Manufacturer>Omega</item:Manufacturer>
97       <item:Model_Name>beam-splitter</item:Model_Name>
98       <item:Model_Number>400DCLP02</item:Model_Number>
99       <item:URI_Var>https://www.omegafilters.com</item:URI_Var>
100    </Item_General_Info>
101  </detectors:Beam_Splitter_Info>
102  <detectors:Emission_Filter_Info Prefix="nano" Unit="meter">
103    <Emission_Filter>Band_Pass</Emission_Filter>
104    <Band_Width_Location>1/e</Band_Width_Location>
105    <Peak_1>619</Peak_1>
106    <Band_Width_1 Band_Width_Location="1/e">
107      <Band_Width>11.2</Band_Width>
108    </Band_Width_1>
109    <Description>token</Description>
110    <Item_General_Info>
111      <item:Manufacturer>Omega</item:Manufacturer>
112      <item:Model_Name>narrow-band emission filter</item:Model_Name>
113      <item:Model_Number>618.6NB5.6</item:Model_Number>
114      <item:URI_Var>https://www.omegafilters.com</item:URI_Var>
115    </Item_General_Info>
116  </detectors:Emission_Filter_Info>
117 </channels:Dectector_Info>
118 <channels:Amplifier_Info>
119   <detectors:Mode>Linear</detectors:Mode>
120   <detectors:Gain>1.0</detectors:Gain>
121 </channels:Amplifier_Info>

```

```

122 <channels:Data_Info>
123   <Data_8 Num_Bits_Allocated="8" Num_Bits_Stored="8"/>
124 </channels:Data_Info>
125 <channels:Excitation_Info>
126   <excite:Light_Source_Info>
127     <excite:Light_Source Polarization="None" Emitter="Hg-Xe">Arc</excite:Light_Source>
128     <excite:Power Prefix="milli" Si_Unit_Name="watt">100</excite:Power>
129     <excite:Wavelength>365</excite:Wavelength>
130     <excite:Description>Standard HgXe arc. This is being replaced by a UV LED</excite:Description>
131     <excite:Item_General_Info>
132       <item:Manufacturer>Hamamatsu</item:Manufacturer>
133       <item:Model_Name>Super-Quiet Mercury Xenon Lamp, Ozone Free Silica</item:Model_Name>
134       <item:Model_Number>L7046</item:Model_Number>
135       <item:URI_Var></item:URI_Var>
136     </excite:Item_General_Info>
137   </excite:Light_Source_Info>
138   <excite:Excitation_Filter_Info Prefix="nano" Unit="meter">
139     <Excitation_Filter>Band_Pass</Excitation_Filter>
140     <Peak_1>365</Peak_1>
141     <Band_Width_1 Band_Width_Location="1/e">
142       <Band_Width>25</Band_Width>
143     </Band_Width_1>
144     <Description>token</Description>
145     <Item_General_Info>
146       <item:Manufacturer>Omega</item:Manufacturer>
147       <item:Model_Name>narrow-band-width</item:Model_Name>
148       <item:Model_Number>365HT25</item:Model_Number>
149
150       <item:URI_Var>https://www.omegafilters.com</item:URI_Var>
151     </Item_General_Info>
152   </excite:Excitation_Filter_Info>
153 </channels:Excitation_Info>
154 <channels:Statistics>
155   <channels:Value>128</channels:Value>
156   <channels:Description>Median</channels:Description>
157 </channels:Statistics>
158 </Channels>
159 </Pixels>
160 <Slide>
161 <slide:Slide_Identifier>2006-08-05.1</slide:Slide_Identifier>
162 <slide:Slide_State>
163   <slide:Slide_State_Identifier>stained</slide:Slide_State_Identifier>
164   <slide:Imaged>true</slide:Imaged>
165 </slide:Slide_State>
166 <slide:Material>probably crown glass</slide:Material>
167 <slide:Transparent>true</slide:Transparent>
168 <slide:Slide_Dimensions>
169   <slide:X_Max Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="25"/>
170   <slide:Y_Max Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="75"/>
171   <slide:Thickness Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="1.00"/>
172 </slide:Slide_Dimensions>
173 <slide:Reference_Area>
174   <slide:Lower_Left>
175     <slide:X_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="1.0"/>
176     <slide:Y_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="64.0"/>
177   </slide:Lower_Left>
178   <slide:Upper_Right>
179     <slide:X_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="24"/>
180     <slide:Y_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="74"/>
181   </slide:Upper_Right>
182 </slide:Reference_Area>

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183 <slide:Specimen_Area>
184   <slide:Lower_Left>
185     <slide:X_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="3.0"/>
186     <slide:Y_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="15"/>
187   </slide:Lower_Left>
188   <slide:Upper_Right>
189     <slide:X_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="21"/>
190     <slide:Y_Offset Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="33"/>
191   </slide:Upper_Right>
192 </slide:Specimen_Area>
193 <slide:Item_General_Info>
194   <item:Manufacturer>Fisher Scientific</item:Manufacturer>
195   <item:Model_Name>Superfrost Plus</item:Model_Name>
196   <item:Model_Number>12-550-15</item:Model_Number>
197   <item:URI_Var>https://www1.fishersci.com</item:URI_Var>
198 </slide:Item_General_Info>
199 <slide:Mounting_Medium>
200   <slide:Item_General_Info>
201     <item:Manufacturer>Surgipath Medical Industries Inc.</item:Manufacturer>
202     <item:Model_Name>Clearium Mounting Medium</item:Model_Name>
203     <item:URI_Var>http://www.surgipath.com</item:URI_Var>
204   </slide:Item_General_Info>
205 </slide:Mounting_Medium>
206 <slide:Coverslip>
207   <slide:X_Length Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="18"/>
208   <slide:Y_Length Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="18"/>
209   <slide:Coverslip_Minimum_Thickness Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="0.13"/>
210   <slide:Coverslip_Maximum_Thickness Prefix_Case_Sen="m" Si_Unit_Name="meter" Value="0.17"/>
211 <slide:Item_General_Info>
212   <item:Manufacturer>Fisher Scientific</item:Manufacturer>
213   <item:Model_Name>Prmium Cover Glasses</item:Model_Name>
214   <item:Model_Number>Size: 18 x 18mm</item:Model_Number>
215   <item:URI_Var>https://www1.fishersci.com</item:URI_Var>
216 </slide:Item_General_Info>
217 </slide:Coverslip>
218 <slide:Description>slide, mounting medium, and coverslip used for image</slide:Description>
219 </Slide>
220 <Transmission_Medium>
221   <trans:Simple_Medium>
222     <trans:Simple_Medium>glycerol</trans:Simple_Medium>
223     <trans:Item_General_Info>
224       <item:Manufacturer>Calbiochem</item:Manufacturer>
225       <item:Model_Name>Glycerol, Molecular Biologytoken</item:Model_Name>
226       <item:Model_Number>356352</item:Model_Number>
227       <item:Item_Lot-number>B28882</item:Item_Lot-number>
228       <item:URI_Var>http://www.emdbiosciences.com</item:URI_Var>
229     </trans:Item_General_Info>
230   </trans:Simple_Medium>
231   <trans:Refractive_Index>1.4746</trans:Refractive_Index>
232   <trans:Description>Glycerol was used because it does not fluoresce under 365 nm excitation, while
immersion oil does.</trans:Description>
233 </Transmission_Medium>
234 <Microscope Sorts="false" Platform="Upright" Viewing="Mono" optics:Objective_List="Oil60x" Carrier="Solid">
235   <instr:Item_General_Info>
236     <item:Manufacturer>Leica</item:Manufacturer>
237     <item:Model_Name>MPVII</item:Model_Name>
238     <item:Model_Number>Unknown</item:Model_Number>
239     <item:Item_Serial-number>Unknown</item:Item_Serial-number>
240     <item:URI_Var>http://www.leica-microsystems.com</item:URI_Var>
241   </instr:Item_General_Info>
242   <instr:Objective Chromat="Semi-Apochromat" id="Oil60x" Immersion="Oil" Magnification="60" Field_Flatness
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243 <optics:Cut_Offs High_Cut_Off="1000" Low_Cut_Off="350" Band_Width_Location="1/2 height"/>
244 <optics:Working_Distance Prefix_Case_Sen="μ" Si_Unit_Name="meter" Value="120"/>
245 <optics:Item_General_Info>
246 <item:Manufacturer>Olympus</item:Manufacturer>
247 <item:Model_Name>UPLFN</item:Model_Name>
248 <item:Model_Number>60XOI</item:Model_Number>
249 <item:Item_Serial-number>Unavailable</item:Item_Serial-number>
250 <item:URI_Var>http://www.olympusamerica.com</item:URI_Var>
251 </optics:Item_General_Info>
252 </instr:Objective>
253 <instr:Condenser Chromat="Achromat" id="Oil_1.3" Immersion="Air" Field_Flatness="Plan" Contrast="None"
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254 <optics:Item_General_Info>
255 <item:Manufacturer>Leica</item:Manufacturer>
256 <item:Model_Name>Came with Microscope</item:Model_Name>
257 <item:URI_Var>http://www.leica-microsystems.com</item:URI_Var>
258 </optics:Item_General_Info>
259 </instr:Condenser>
260 <instr:Comments>The condenser was not used to obtain this image.</instr:Comments>
261 </Microscope>
262 </image:Image>
263
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