



THINK.CHANGE.DO

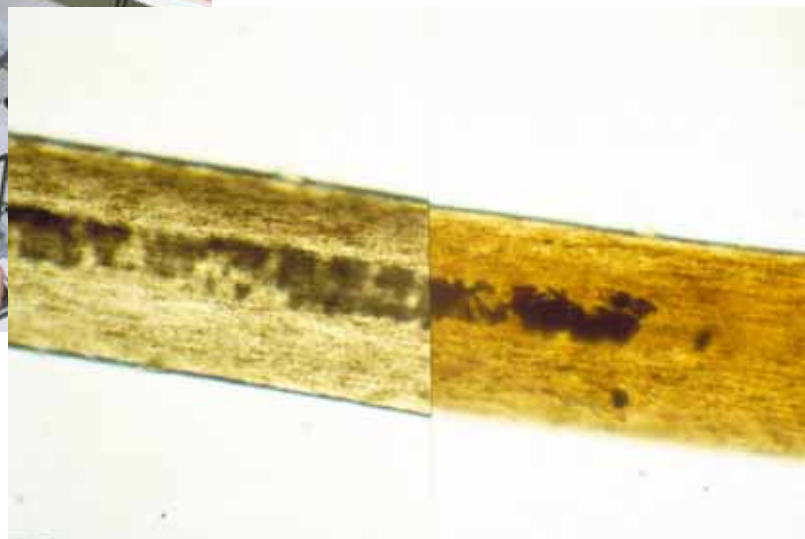
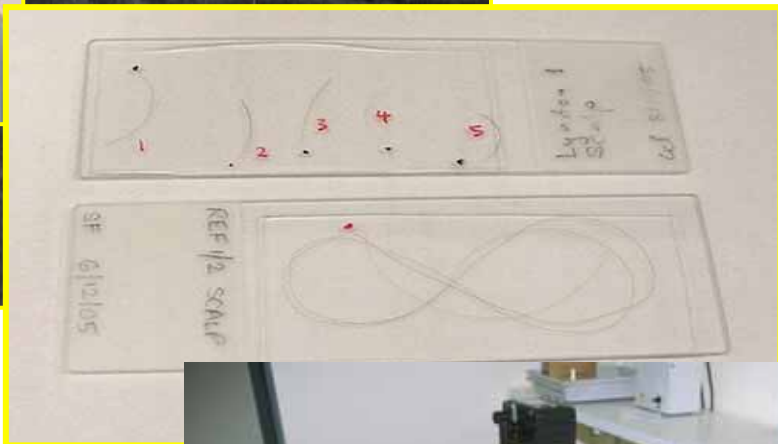
Discrimination of Human Hairs Using Color Measurements and Digital Microscopy

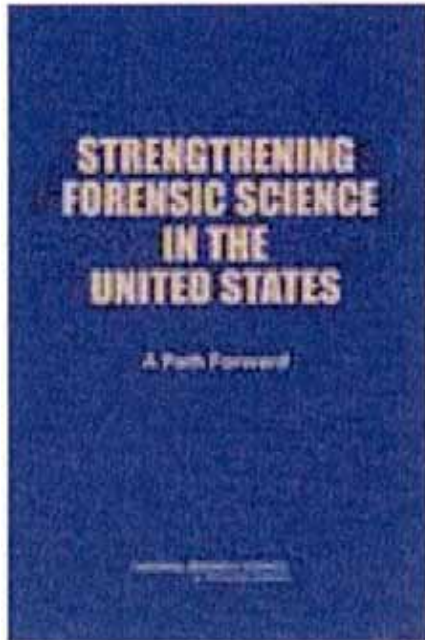
Claude Roux¹, Liz Brooks^{2,3}, Lisa Masaki¹, Chris Lennard³ and James Robertson²

1. Centre for Forensic Science, University of Technology, Sydney, Australia
2. Forensic & Data Centres, Australian Federal Police, Canberra, Australia
3. National Centre for Forensic Studies, University of Canberra



Hair Examination





Strengthening Forensic Science in the United States: A Path Forward

Committee on Identifying the Needs of the Forensic Sciences Community; Committee on Applied and Theoretical Statistics, National Research Council

ISBN: 0-309-13131-6, 254 pages, 6 x 9, (2009)

This PDF is available from the National Academies Press at:
<http://www.nap.edu/catalog/12589.html>

- No scientifically accepted statistics exist about the frequency with which particular characteristics of hair are distributed in the population.
- There appear to be no uniform standards on the number of features on which hairs must agree before an examiner may declare a “match.”





REPORT OF THE
COMMISSION OF INQUIRY
INTO CERTAIN ASPECTS OF
THE TRIAL AND CONVICTION OF
JAMES DRISKELL

◆

THE HONOURABLE PATRICK J. LESAGE, Q.C., COMMISSIONER

January 2007



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Hair as Evidence

Testimony of Mr Peter Neufeld
(Driskell Inquiry, 2006, page 5585)

“There is no question, and I think everyone in the room would agree, that DNA [nuclear DNA] is a far more robust forensic science that [than] is hair microscopy. It is speculative, actually, to suggest that hair microscopy still can play a useful role in the forensic science or criminal justice adjudicatory process....”

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Hair Evidence 'on Trial'

- Criticisms of hair evidence are such that it is reasonable to ask -
- What is the future of forensic hair examination?
 1. Do we just ignore hair evidence (too hard!), maybe occasionally undertaking mtDNA analysis? [ad-hoc approach]

OR

2. Do we consider hair as a given type of trace that combines both morphological and biological information whose value and limitations are well understood and that must be examined in a holistic manner?



Microscopic Examination

- Integral part of the holistic approach to trace evidence (hence to hair too).
- However, since the advent of DNA, it has become the 'weakest link'.
- We must actively investigate further the means of objectively examining hair under the microscope.
- Significant work in this area at the AFP in collaboration with UC over the last 5 years (Brooks, Robertson et al.), more recently with UTS and University of Adelaide.



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Numerical Analysis of Hair

- Three elements:
 - Element 1: digital imaging and image montaging
 - Element 2: image analysis and production of numerical data
 - Element 3: analyses of objective measures of the human hair features of color and pigmentation



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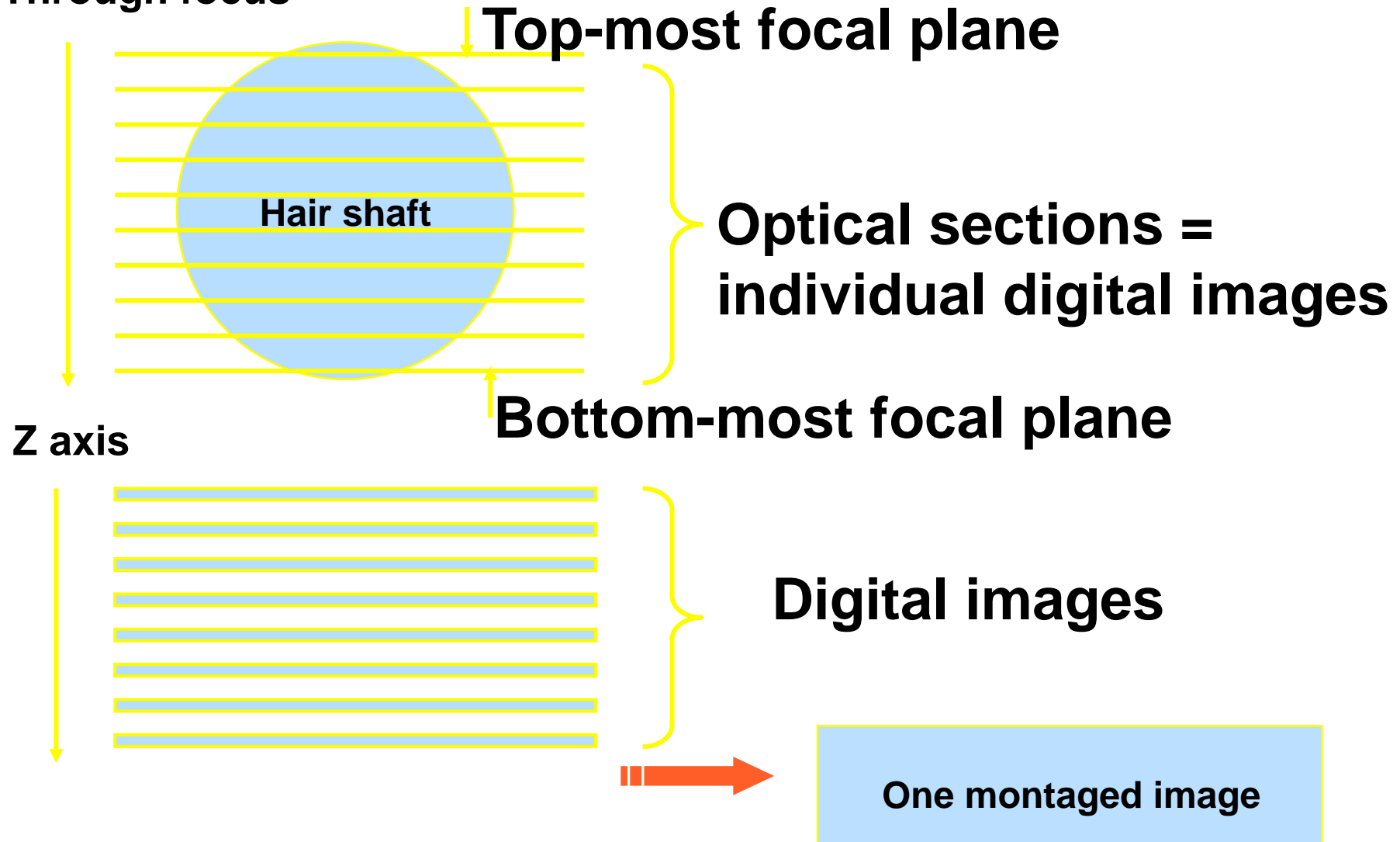
Equipment

- Olympus DP70 digital camera attached to a Leica Diaplan compound microscope, 400× magnification
- Syncroscopy Automontage Software vertically stacks images to produce a single 'in focus' image.
- Image analysis - V ++ for Windows (Digital Optics Ltd)



Digital Imaging and Image Montaging

Through focus





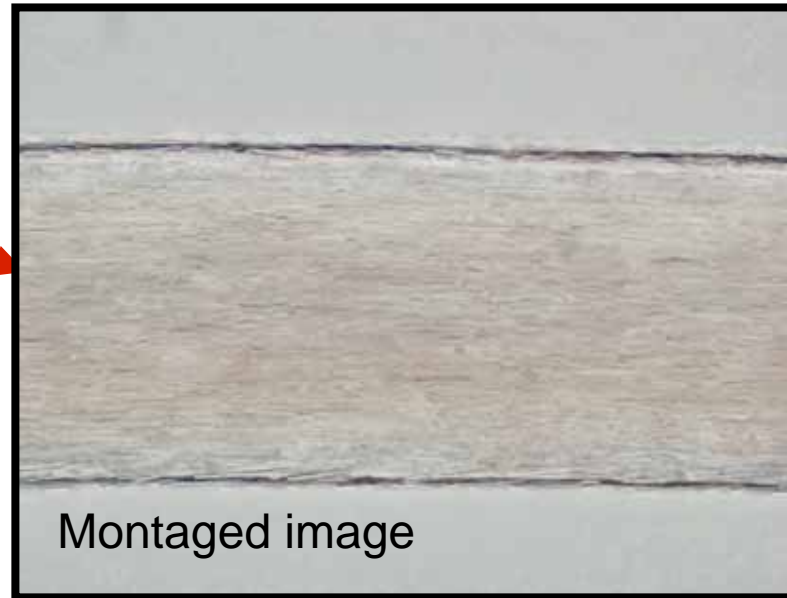
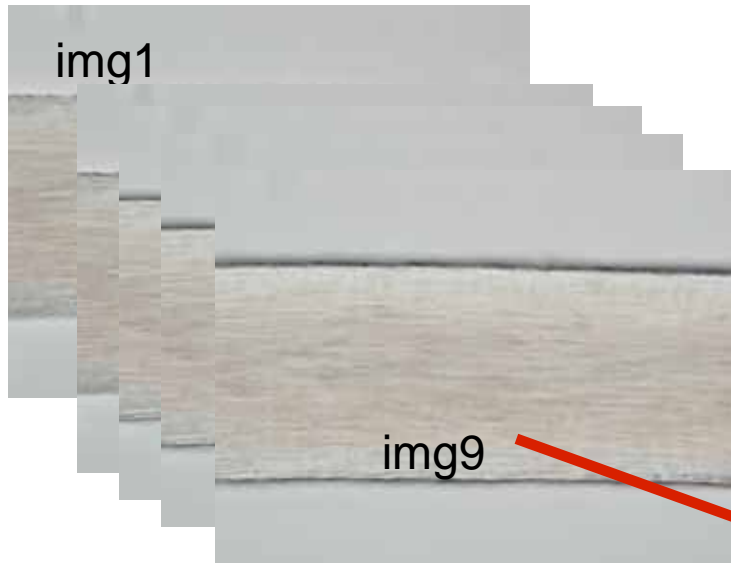
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Example of Montage



Source: original images



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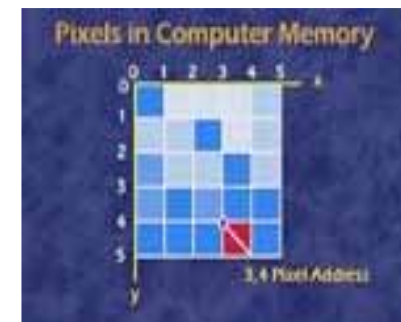
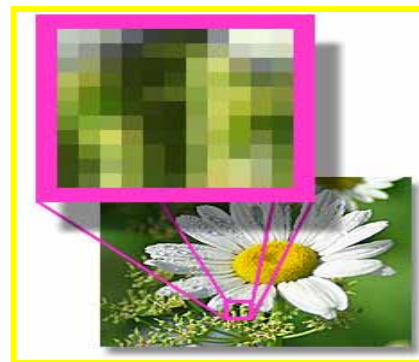
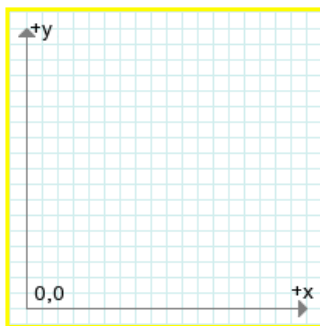
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Image Analysis

- Digital image is composed of a pixel array representing a series of intensity values
- Organised (x,y) Cartesian coordinate system which means each pixel has a computer 'address'
- coordinate system enables numerical values to be assigned to the features observed within the image





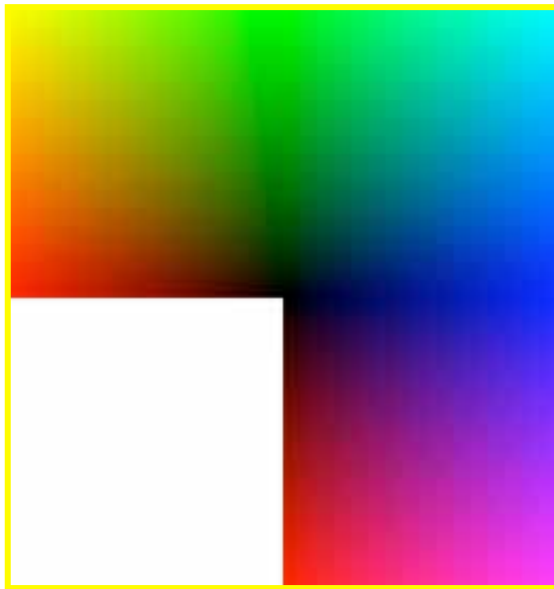
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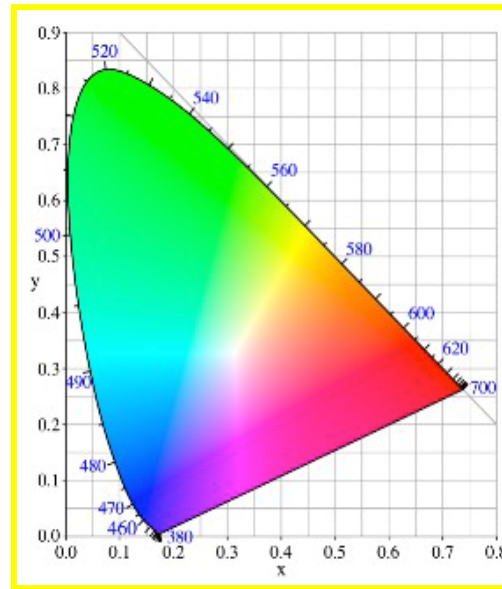


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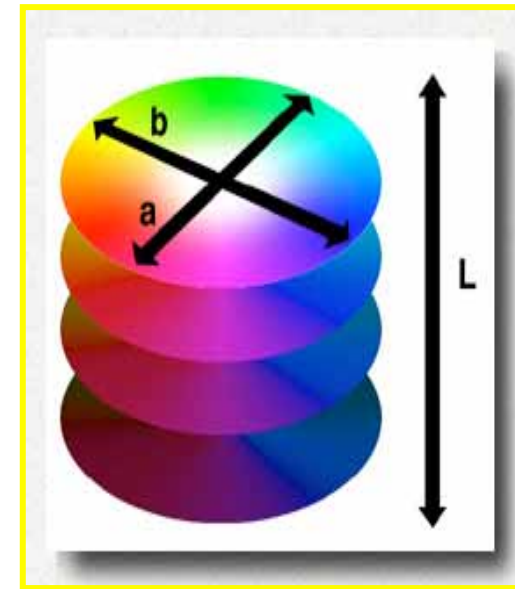
Image Analysis of color



Amounts of
red, green &
blue



3 wavelengths X, Y
and Z – direct
measurement of
human eye

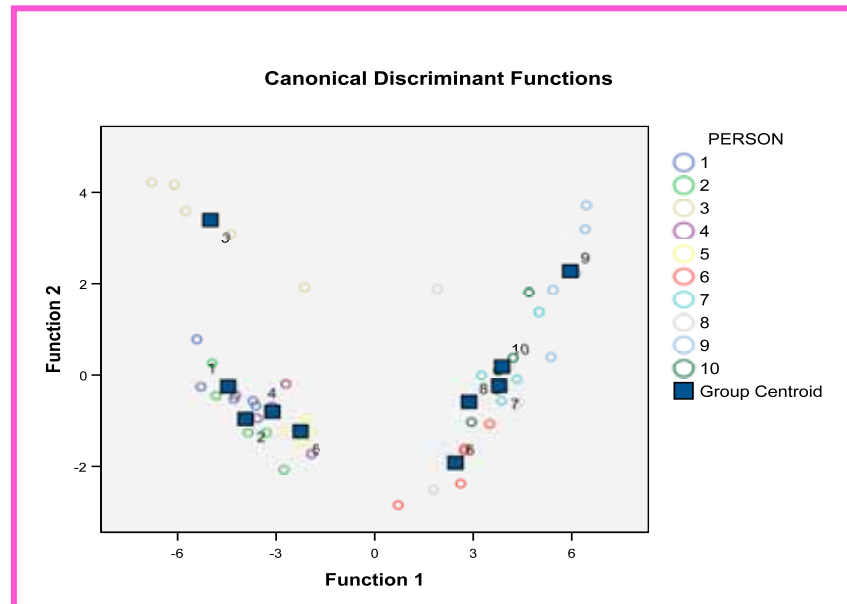


L: luminance
a: green to red
b: blue to yellow



Experiment Using Brown Caucasian Hair color

- Associate the 10 image sets (25 montaged images) with the donor of the hair
- Discriminate between 10 image sets of brown haired individuals





Experiment on Wider Variations of Hair color

	color model	Hair color group			
		Blond	Black	Brown	Red
Casewise analysis % individual hairs correctly allocated	<i>RGB</i>	27.3	54.3	60	51.4
	<i>XYZ</i>	30.3	51.4	51.4	50
	<i>LAB</i>	33.3	57.1	60	54.3
Pairwise Analysis % paired cases where centroids were different	<i>RGB</i>	38.1	42.8	71.4	52.4
	<i>XYZ</i>	38.1	42.8	71.4	52.4
	<i>LAB</i>	38.1	57.1	76.2	52.4



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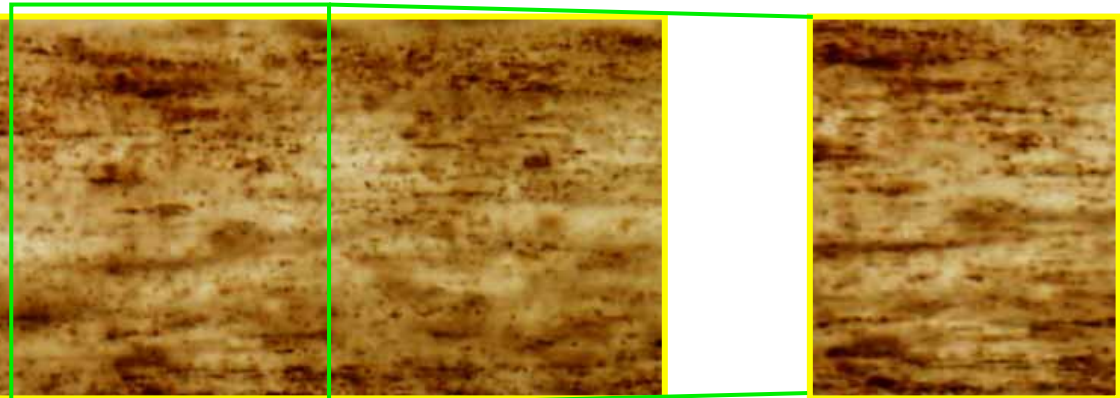
"Pattern Extraction from image "Template"

color image from Person 10, Hair Sample B-3, optical section



Original digital image

Sample 10B-3-45



**Pattern extract
10B-3-45**



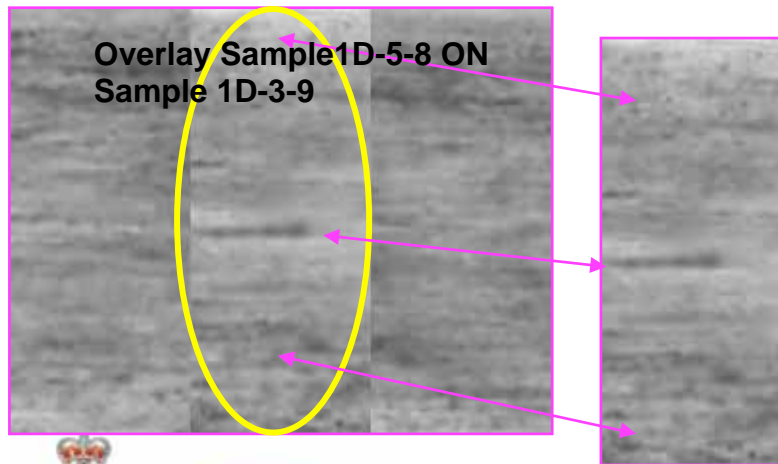
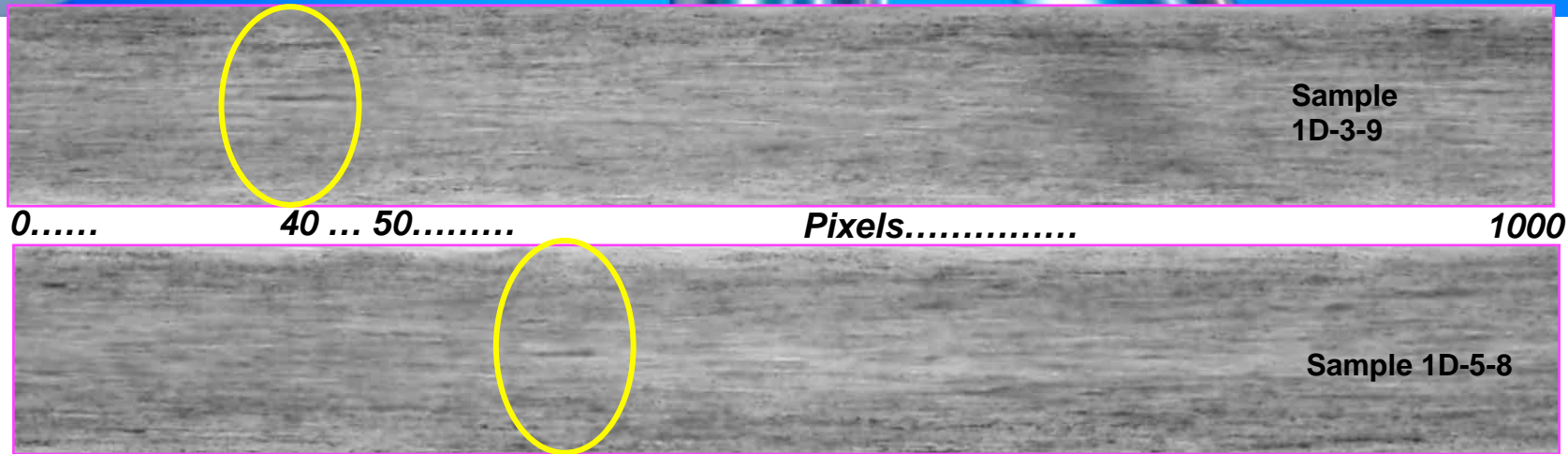
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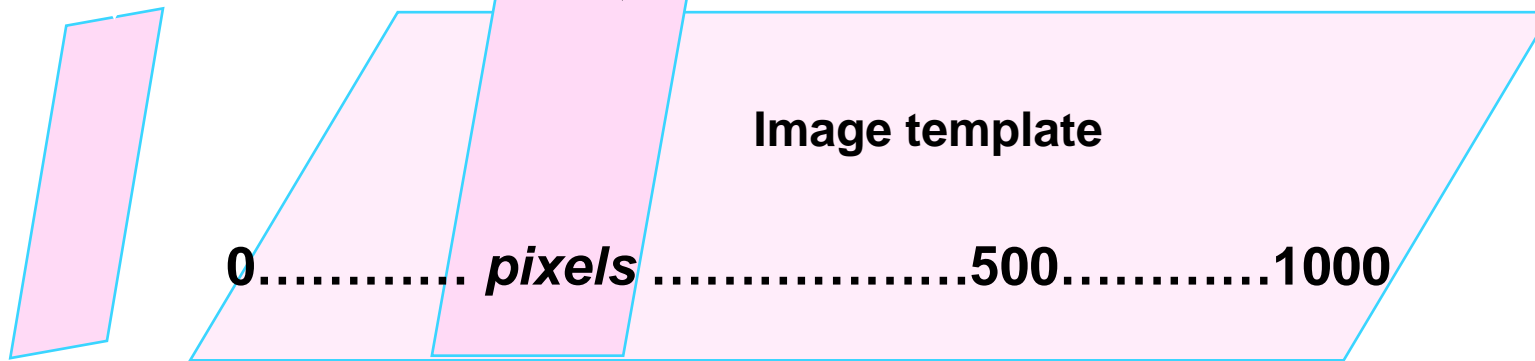
Pigment Pattern Identification





Generation of Pattern Matching Values

Pattern Match



Extracted
Pattern

No Pattern Match



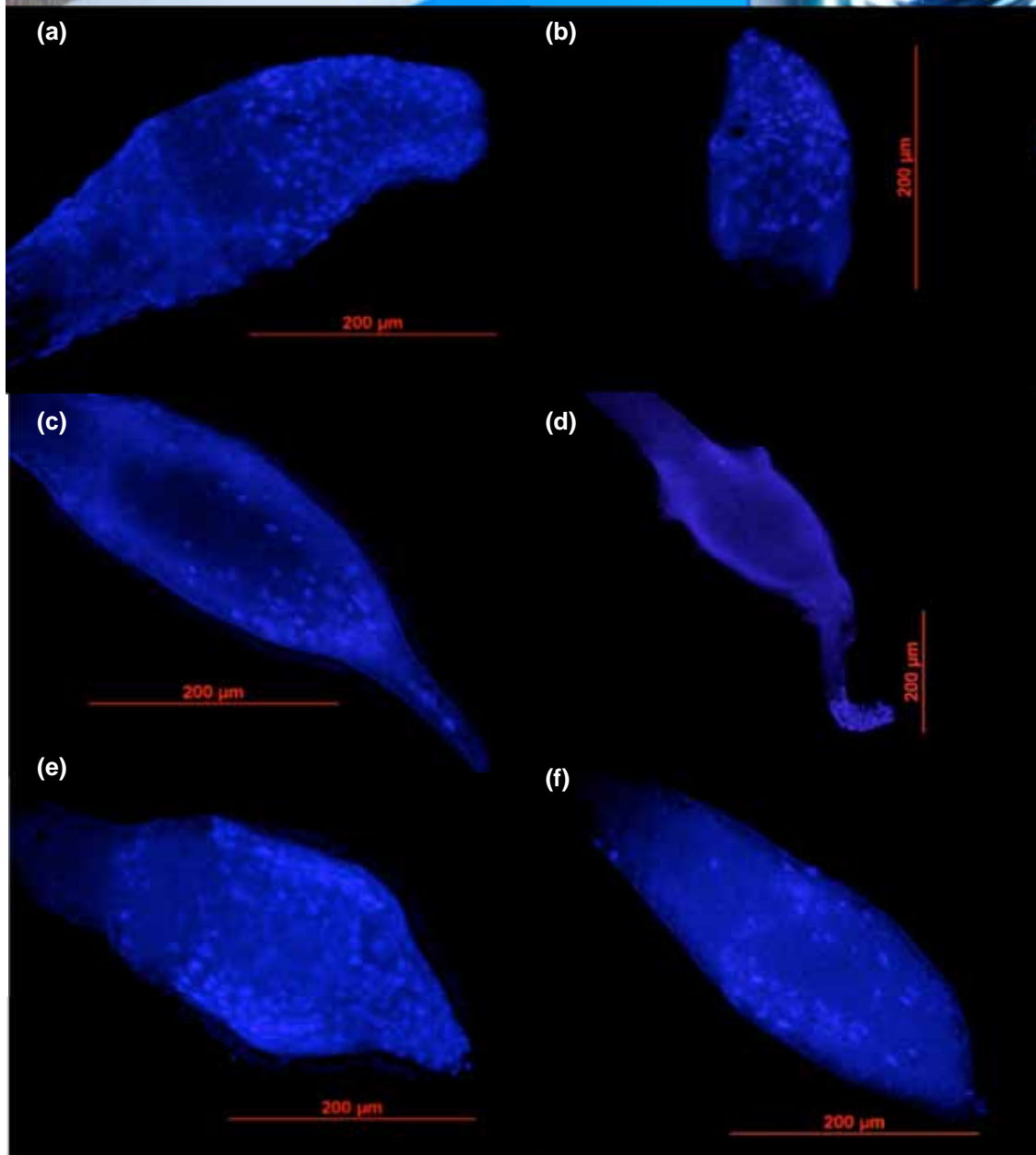


Pigment Pattern Analysis - Experiment on Blond Hairs

	Probabilities of log(mean+1)						
<i>Hair</i>	BD1	BD2	BD3	BD4	BD5	BD6	BD7
1	0.8770	0.2514	0.7764	0.5517	0.6064	0.0516	0.1423
2	0.5832	0.4364	0.5438	0.0526	0.0838	0.1075	0.0548
3	0.8810	0.7704	0.6217	0.7764	0.3632	0.4207	0.0427
4	0.4840	0.4207	0.1711		0.0655	0.4801	0.1562
5	0.6628	0.1922	0.7357		0.1210	0.6480	0.2946

The probabilities that the log mean values obtained exceeded the mean value obtained from persons matched with themselves.



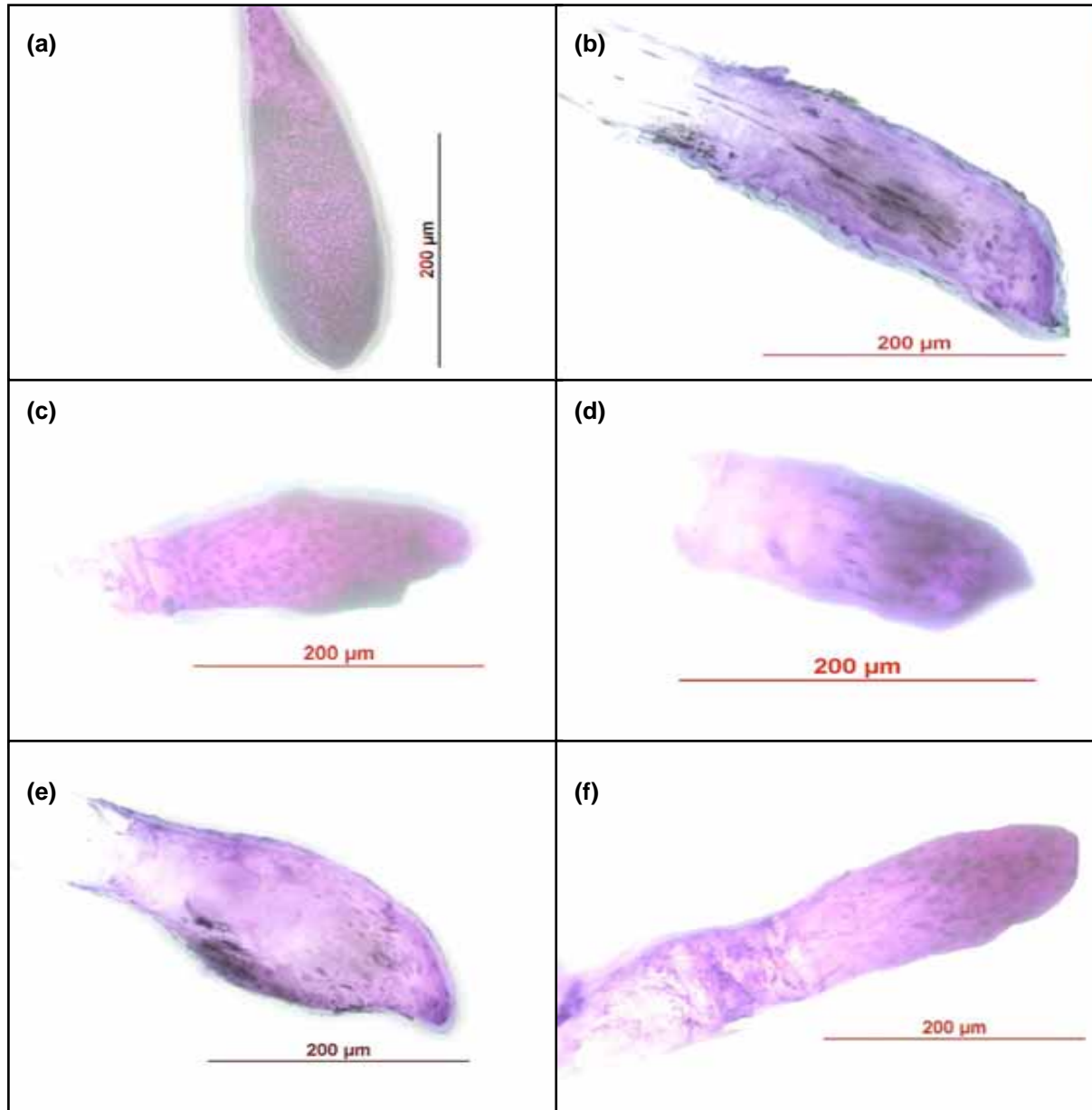


Telogen Hairs

- Where is nDNA and how much?
- Examples of Telogen Hair Roots with **>30** Nuclei DAPI Staining



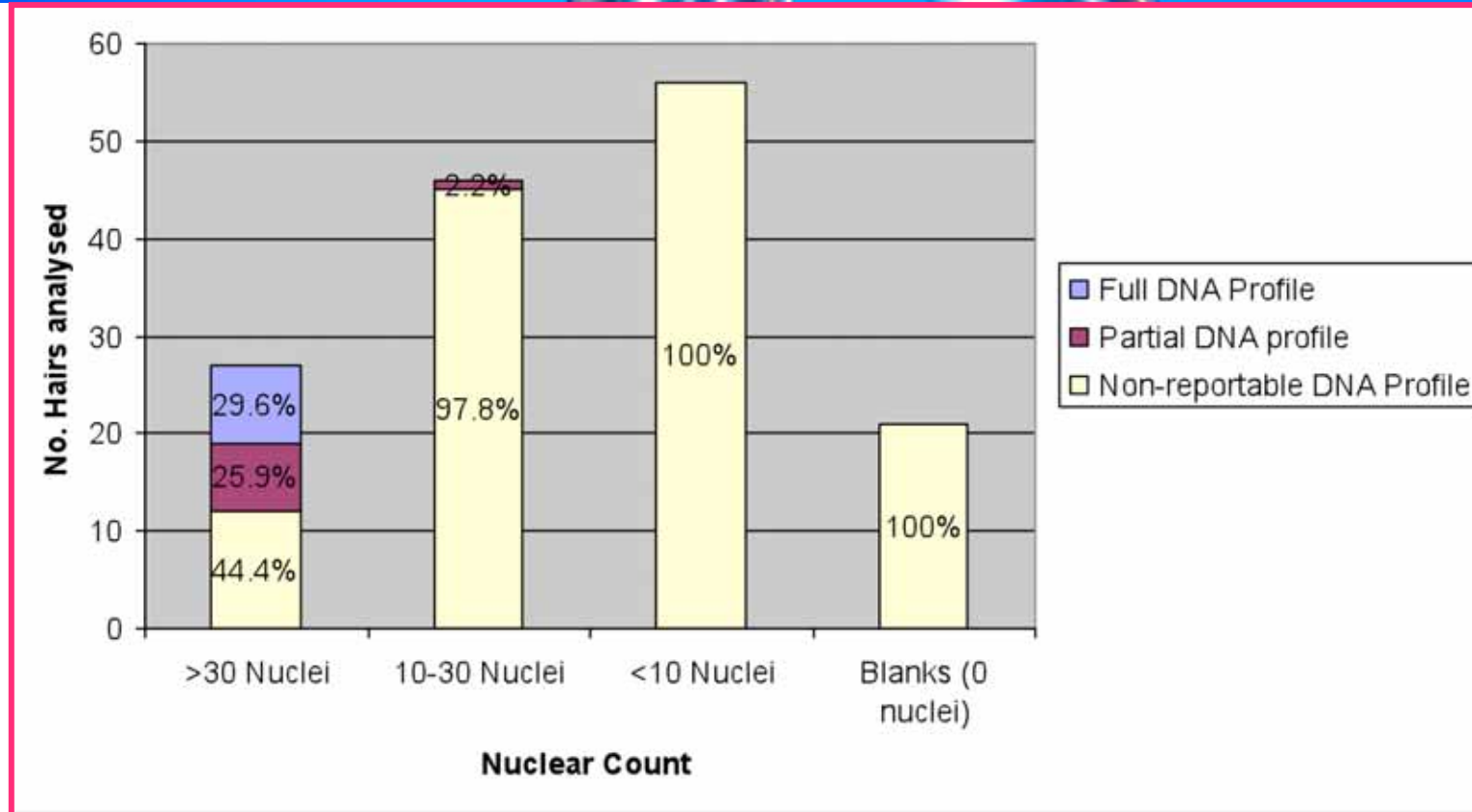
Telogen Hairs



- Where is nDNA and how much?
- Examples of Telogen Hair Roots with **>30** Nuclei Harris's Haematoxylin Staining



Success of nDNA Analyses of Hairbrush Samples in Each Nuclear Count Group



Percentage of hairs that produced full, partial or non-reportable DNA profiles separated according to nuclear count. Successful DNA typing was predominantly observed in telogen roots with greater than 30 nuclei.



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MEDIA RELEASE

SENATOR KIM CARR

Minister for Innovation, Industry, Science and Research

Wednesday, 28 May 2008

'Silent witness' research to revolutionise forensics

\$63 million in new ARC grants announced

A radical new hair examination technique that is set to revolutionise forensic science is one of 208 new research projects sharing in \$63,717,139 over five years, the Minister for Innovation, Industry, Science and Research, Senator Kim Carr, announced today.

The University of Canberra "Silent Witness" project is a collaboration with the Australian Federal Police and Leica Microsystems Pty Ltd, and aims to improve the quality of evidence drawn from human hair.



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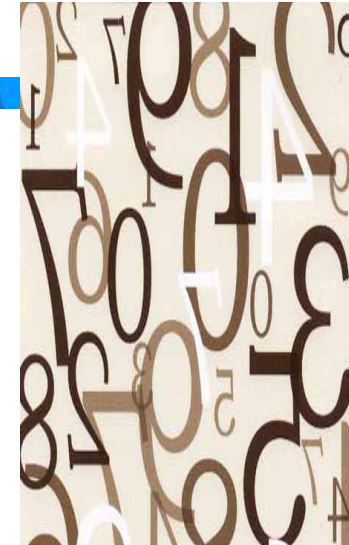
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Aims of the ARC Project

- To produce an objective, numerical-based system for identifying “matches” among hair samples
 - color models: RGB, CIE L*a*b*, CIE XYZ
 - Pigment pattern recognition
 - Chemical imaging
 - X-ray diffraction
- To investigate the actual location of DNA (telogen hairs) and develop new methods, drawing on ancient DNA research which focuses on use of degraded and low copy specimens
- Compare the discriminating powers of these approaches
- New screening sequence and protocol for hair examination



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Conclusions

- Resurgence of research into forensic hair examination
- Crucial to adopt a holistic approach to hair examination; as opposed to a competing view 'microscopy vs. DNA
- Color analysis and pigment pattern recognition are promising as processes to generate objective numerical values
- These techniques may assist to develop large scale surveys never undertaken with hairs so far
- DNA staining methods are promising as part of a novel screening sequence – focus back on microscopy!



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The 20th International Symposium on the Forensic Sciences

5 - 10 September 2010

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