

**Summit on Color in Medical Imaging, May 8-9, 2013  
FDA White Oak Campus, Silver Spring, MD, USA**

Section III

Dermatology, Ophthalmology and Medical Photography

**Color Reproduction in Medical Diagnosis**

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# Importance of Color in Medicine (1)

Inconsistent color reproduction may cause severe **diagnostic errors**.



**fever**



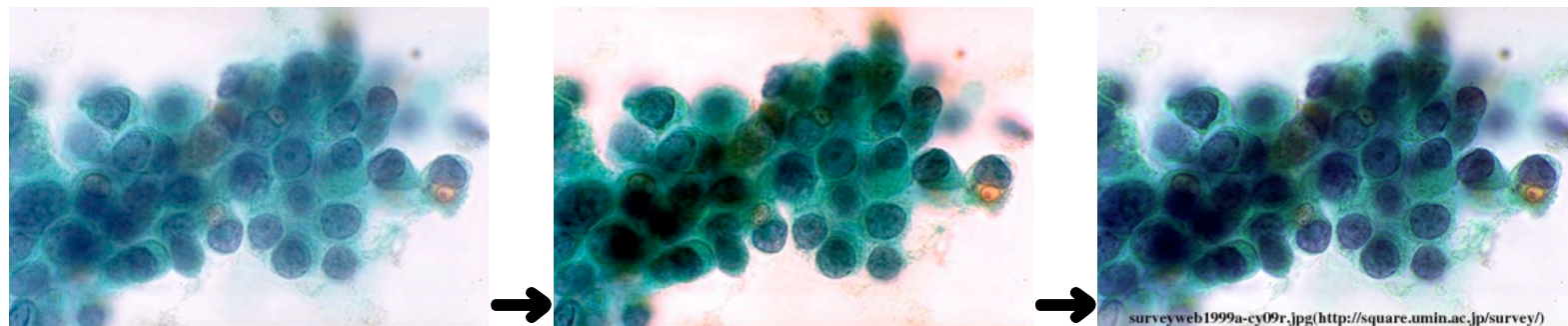
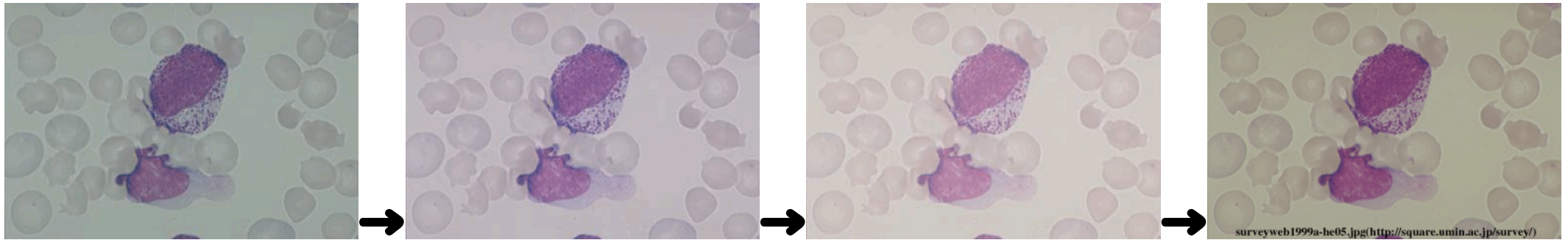
**normal**



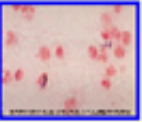
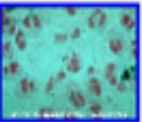
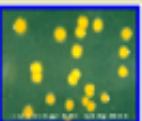
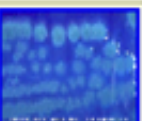
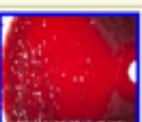



**anemia**

# Importance of Color in Medicine (2)

In a laboratory, precisely **correct color reproduction** is required.



# Quality of Colors on Various Displays

Image No.	Image	Display equipment						
		No.1	No.2	No.3	No.4	No.5	No.6	No.7
		CRT1	CRT2	CRT3	CRT4	LCD1	LCD2	LCD3
M-01		6.0	6.0	6.0	6.0	6.0	6.0	6.0
M-02		6.0	6.0	6.0	3.0	6.0	4.0	4.0
M-03		6.0	6.0	6.0	6.0	6.0	6.0	3.0
M-04		6.0	6.0	6.0	6.0	6.0	6.0	6.0
M-05		6.0	6.0	6.0	6.0	6.0	6.0	3.0
M-06		6.0	6.0	3.0	2.0	4.0	2.0	2.0
M-07		6.0	6.0	4.0	4.0	4.0	4.0	4.0
M-08		6.0	6.0	6.0	4.0	6.0	6.0	4.0

Resolution of these displays is almost the same, but the performance of **color reproduction** varies. The highest grade was determined as '6' and grade lower than '3' means unusable. A grade of equipment No.7 was varied from the highest to unusable. Specimen M-01 and 04 got the highest grade with all devices, but specimen M-06 **varied from the highest to unusable**. A user watching one display may not notice this fact, which may incidentally **cause erroneous diagnosis**.

# Color Reproduction and Illuminants

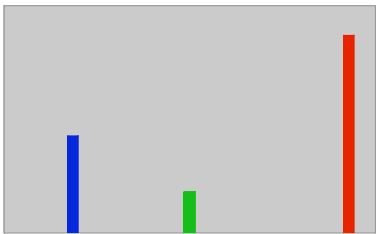
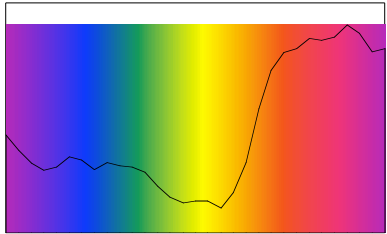
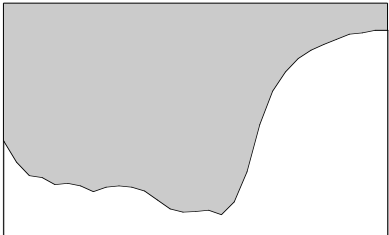
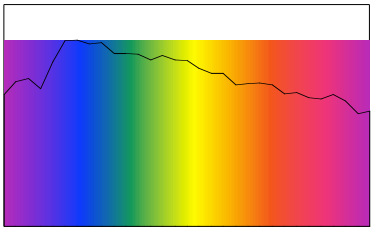
Color of an object will be **changed** in different **illuminant** conditions.

illuminant  
spectral  
radiation

spectral  
reflectance  
of a object

spectrum of  
reflected  
light

RGB



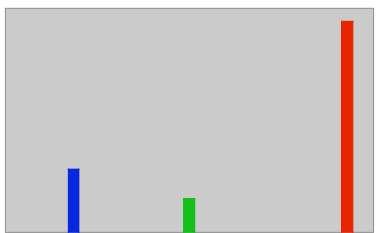
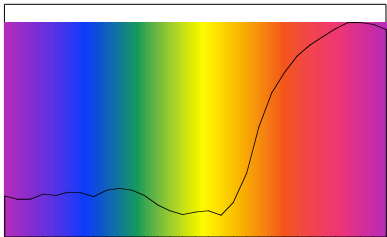
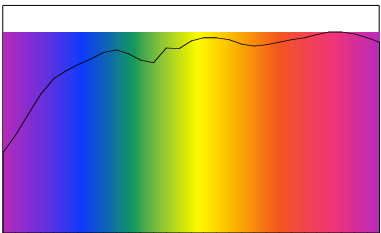
↑ ↓

X

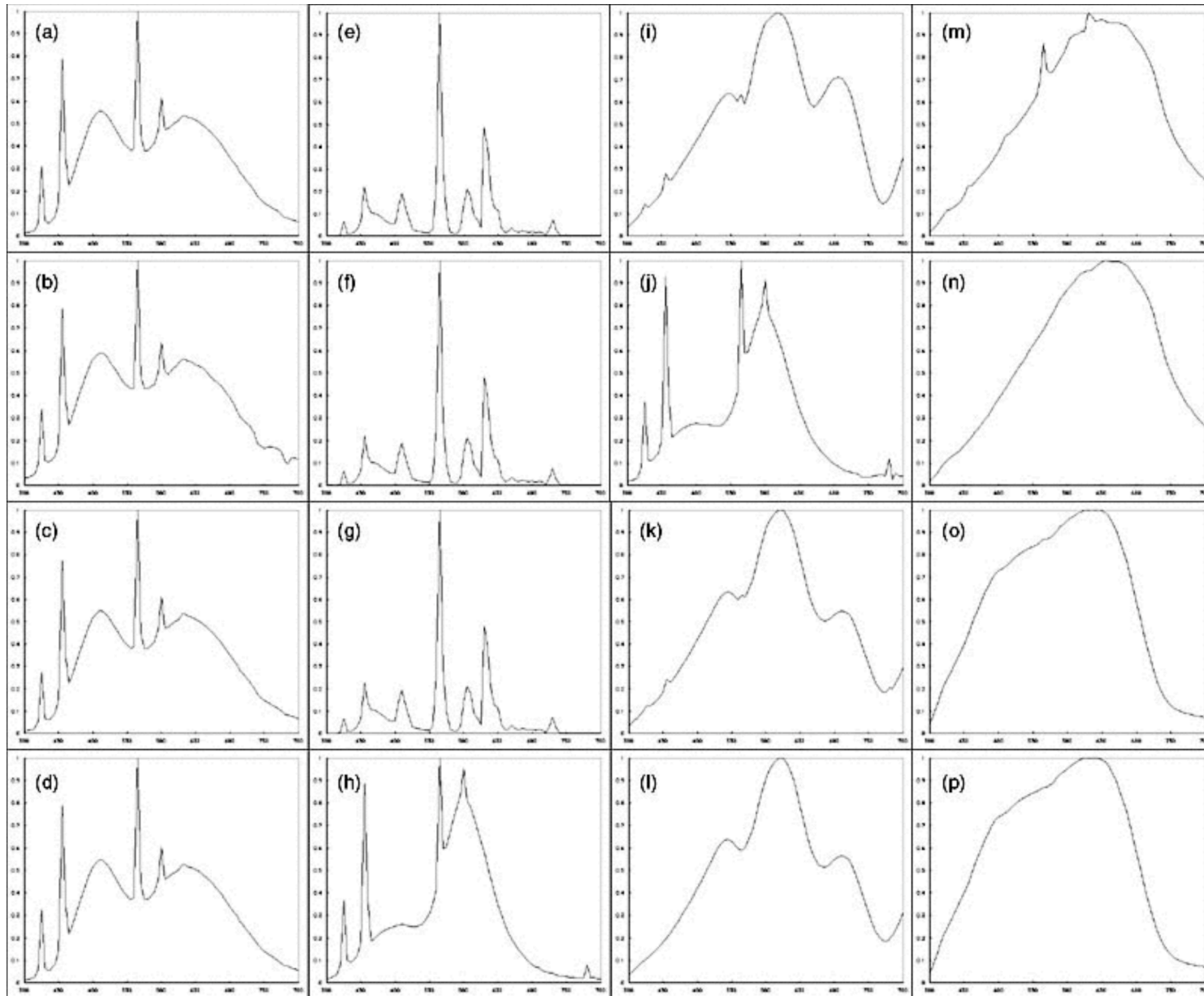
=

↑ ↓

∩



# Various illuminant conditions in a hospital



Spectral radiant distributions from 380 nm to 780 nm of wavelength measured at the following places.

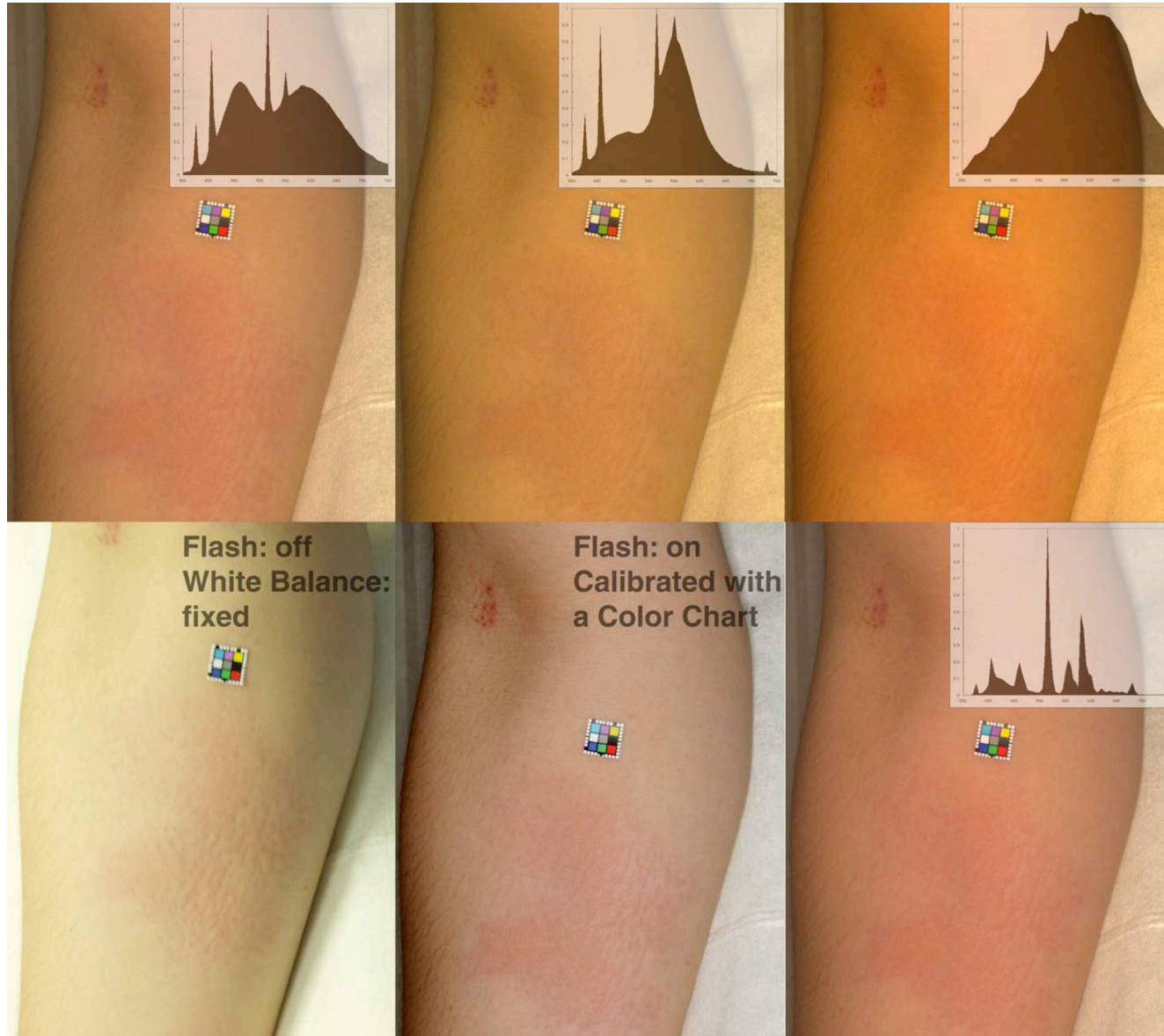
<u>Place</u>	<u>Angles of measured plane</u>	<u>Ceiling light</u>	<u>Other lighting sources</u>
[a] An outpatient booth of dermatology	45° to the horizontal	on	(windows aside)
[b] An outpatient booth of dermatology	45° to the horizontal	on	(facing to windows)
[c] An outpatient booth of dermatology	vertical	on	(windows aside)
[d] An outpatient booth of dermatology	horizontal	on	(windows aside)
[e] A treatment room of a dermatology ward	45° to the horizontal	on	(none)
[f] A treatment room of a dermatology ward	vertical	on	(none)
[g] A treatment room of a dermatology ward	horizontal	on	(none)
[h] An emergency outpatient unit	45° to the horizontal	on	(none)
[i] A dental chair by the window	horizontal	on	an adjustable lamp
[j] A dental chair by the window	horizontal	on	[windows aside)
[k] A dental chair apart from the window	horizontal	on	an adjustable lamp
[l] A dental chair apart from the window	horizontal	off	an adjustable lamp
[m] A surgical bed in an operating room A	horizontal	on	surgical lights
[n] A surgical bed in an operating room A	horizontal	off	surgical lights
[o] A surgical bed in an operating room B	horizontal	on	surgical lights
[p] A surgical bed in an operating room B	horizontal	off	surgical lights

# Measuring Spectral Reflectance of Skin

- Pictures including **spectral reflectance** for each pixel could reproduce colors under any illuminants, but such pictures are difficult to be captured in reality.
- But skin has only **three major pigments** and the **three principal components** are sufficient to approximate the reflectance spectra of skin, so they can be estimated from a picture taken by a common **three-band** digital camera.

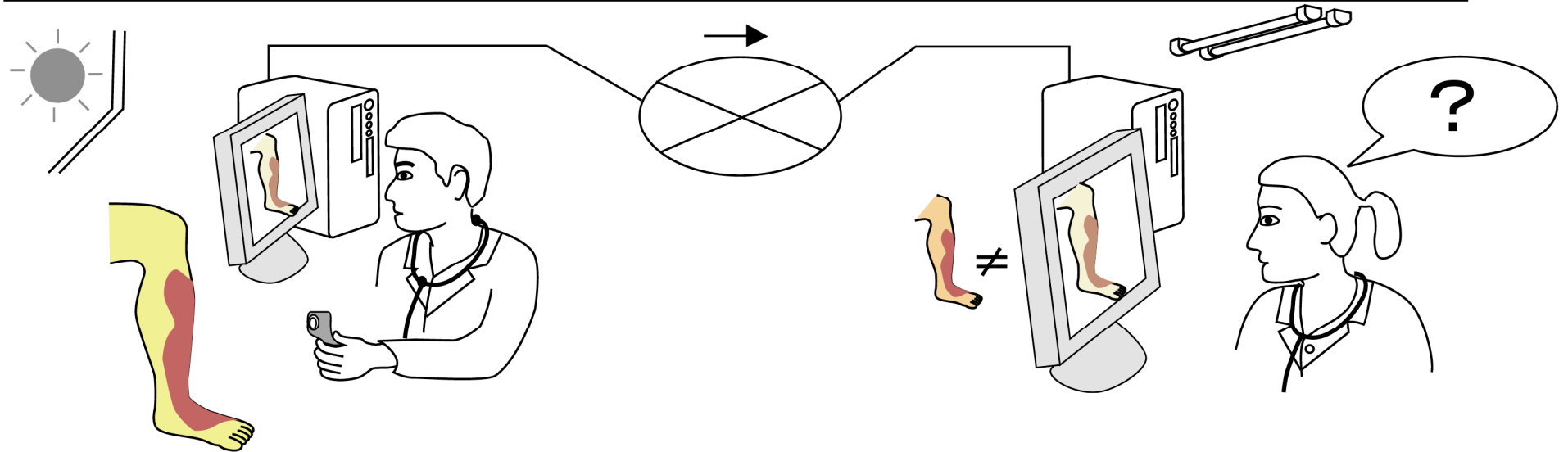


# Estimated Colors under Various Illuminants

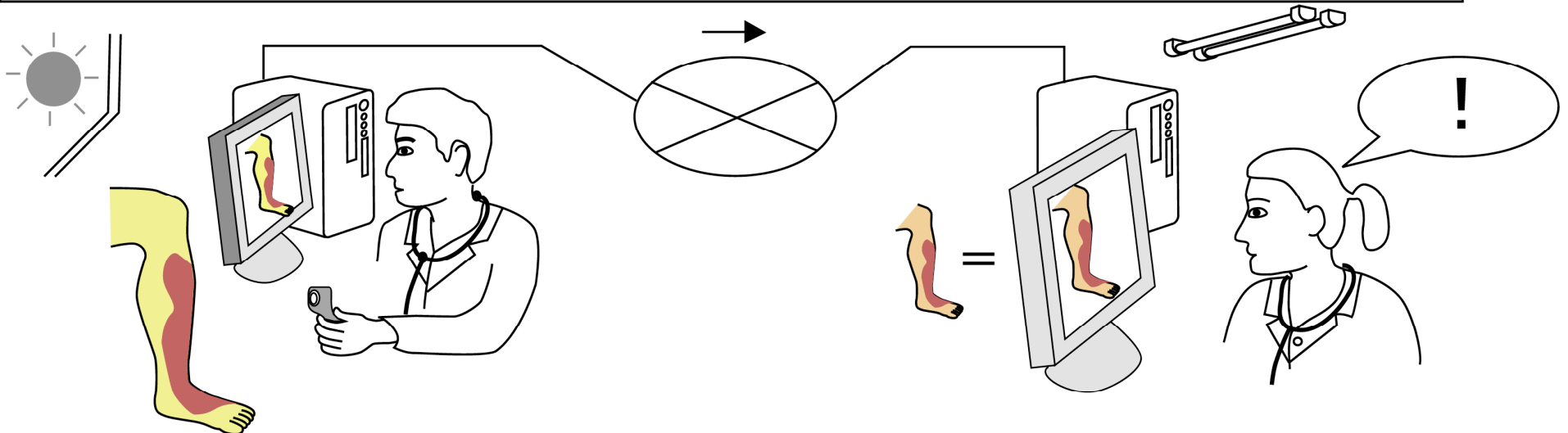


# Correct Colors Make it Work!

Before



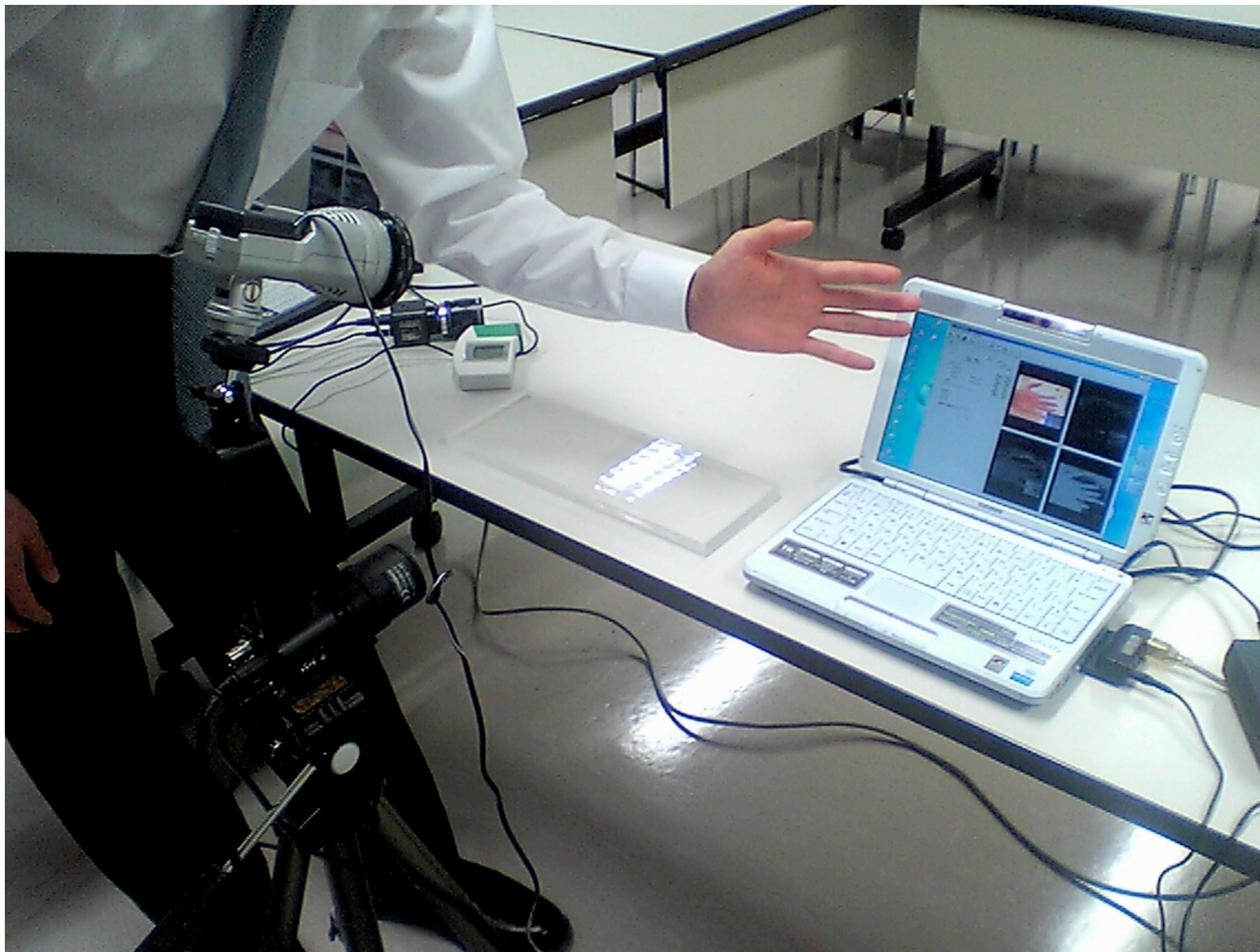
After



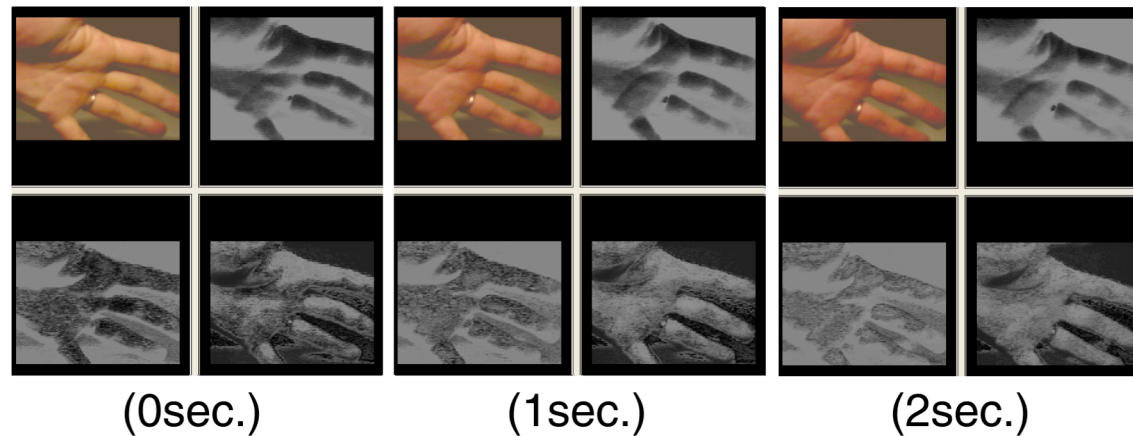
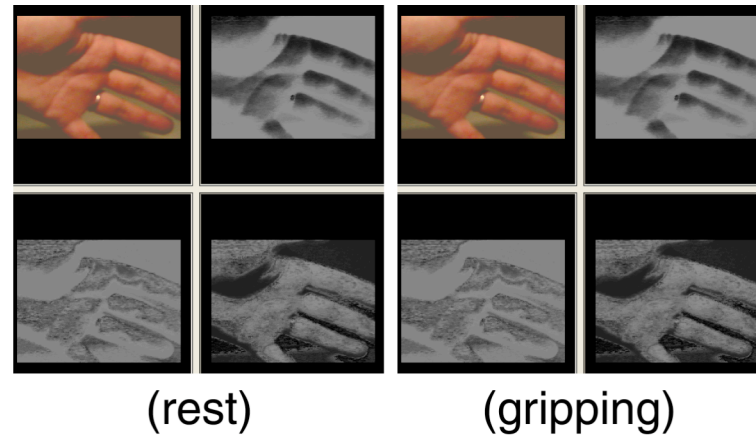
# Spectral Reflectance Makes More!

- The spectral reflectance of each pixel of a skin picture will be used to calculate and **visualize the distribution** of melanin, hemoglobin and **oxyhemoglobin**.
- Various **innovative uses** expected:
  - › very **early detection** of latent decubital ulcers or latent diabetic gangrenes
  - › detection of circulatory insufficiency of a **suture site** that causes its **rupture**
  - › **monitoring** circulation of transplants

# Estimating Spectral Reflectance of Skin

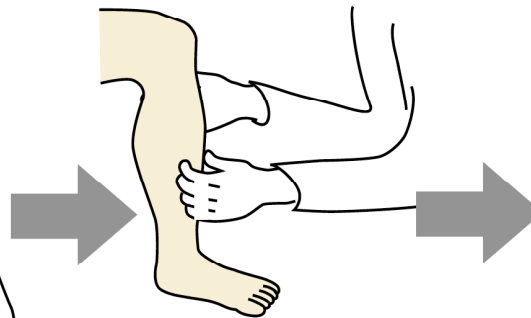
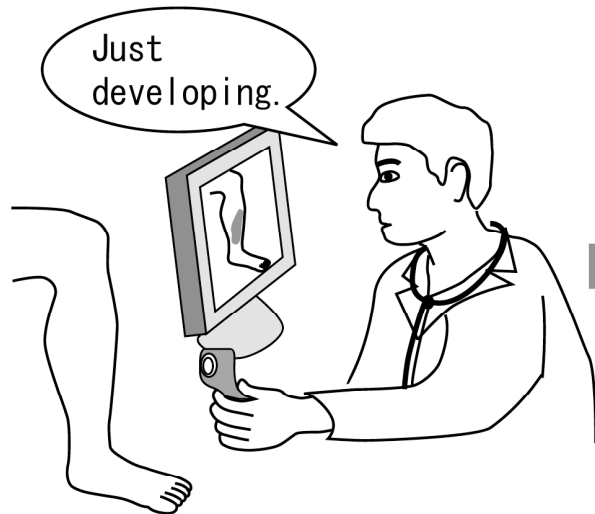
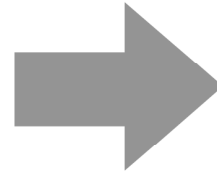
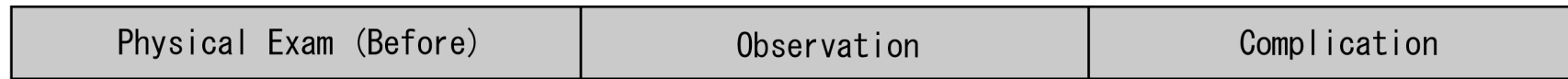


# Estimated Distribution of Skin Pigments



**(Each frame consists of four windows; upper left: illuminant independent color reproduction, upper right: melanin, lower left: hemoglobin, lower right: oxyhemoglobin)**

# Very Early Detection of Latent Lesions



# What one step should we take?

- We should understand that the color is a **dynamically changing** life signal and at present can be captured and recorded only in fragments.
- We should introduce a concept of **'diagnostic equivalence'**, which means that two equipments reproducing colors differently are considered as medically equivalent if the same diagnosis is gotten with them.

**Thank you for your attention**

**Special thanks to Norimichi Tsumura**

**and**

**Valuable Membership of  
Digital Biocolor Society**

**(<http://biocolor.umin.ac.jp/>)**

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