Fluorescence in Dermatology; synopsis

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Abstract

Dermatoscopes are non-invasive, artistic, cost-effective diagnostic and prognostic tools to help identify neoplastic and non-neoplastic skin lesions (inflammatory and infectious), and the augmented ultraviolet and sub-ultraviolet varieties are a revolutionary, innovative auxiliary diagnostic tool to help visualize the non-discernible with the usual conventional dermatoscope. The existing literature however is still in its infancy and is limited by inconsistent and misleading terminology, such as the distinction between fluorescence and reflectance. It also guides the management of inflammatory skin diseases and serves as an aid in monitoring response to therapy and the early detection of treatment-related side effects. There is a need for further studies with larger sample sizes, a high level of evidence, and control groups for a better understanding and consistent terminology.

Ultraviolet-induced fluorescence dermoscopy (UVF dermoscopy) is a novel, portable technique that functions as a miniaturised Wood's lamp for dermatological assessment. It uses a UV light source to induce fluorescence in cutaneous chromophores through the Stokes shift phenomenon, allowing detection of UV-induced fluorescent signals. Initially applied mainly to pigmentary skin tumours,such as malignant melanoma, melanocytic naevi, basal cell carcinoma, and seborrhoeic keratosis, its use has recently expanded. UVF dermoscopy is now increasingly utilised in the evaluation of inflammatory dermatoses, including psoriasis, lichen planus, vitiligo, and porokeratosis, as well as granulomatous and keratinisation disorders, sebaceous gland diseases, and various bacterial and fungal infections.

In fact, UV dermatoscopy complements and doesn't replace the conventional dermatoscopy, by reducing unnecessary excisions and diagnostic biopsies, facilitating early detection of tumour recurrences. Clinicians should be conscious of their peculiarities, artefacts, limitations, and safety concerns to optimize their diagnostic accuracy and ensure patients' safety.

This paper aims to focus on uses, advantages, and limitations, based on the current peer-reviewed literature.

Keywords: dermatoscope, imaging, ultraviolet, ultraviolet-induced fluorescence dermoscopy, biopsy, skin cancer, diagnosis.

Introduction

Within the concept of dermatoscopy, ultraviolet (UV) and sub-UV dermatoscopy has recently emerged as innovative modalities that utilize high-energy, short-wavelength light-emitting diodes (1,2).

The idea of UV dermatoscopy augments conventional dermatoscopy by optimizing safety margins in melanoma, facilitating the detection of tumour recurrence, and enhancing visualization in non-neoplastic conditions, including pigmentation disorders, intertrigo, papulo-desquamative dermatoses, and beyond (3).

Furthermore, ultraviolet-induced fluorescence dermoscopy (UVFD) may improve diagnostic accuracy in non-neoplastic dermatoses, yet data on hair disorders are scarce and underexplored. Additionally, the UVFD has the capacity to detect superficial melanin, which is larger in size and more homogeneous in the superficial layers of skin. Also, its ability to appreciate even subtle pigmentation could aid in determining margin-free lesions, which was shown with histopathology, and the ulcers are believed to be significant prognostic markers for malignant melanoma, which can be better seen on UVFD (3).

The limitations of these techniques include difficulty in differentiating melanin from haemoglobin, challenges in evaluating uneven surfaces, and artefacts.

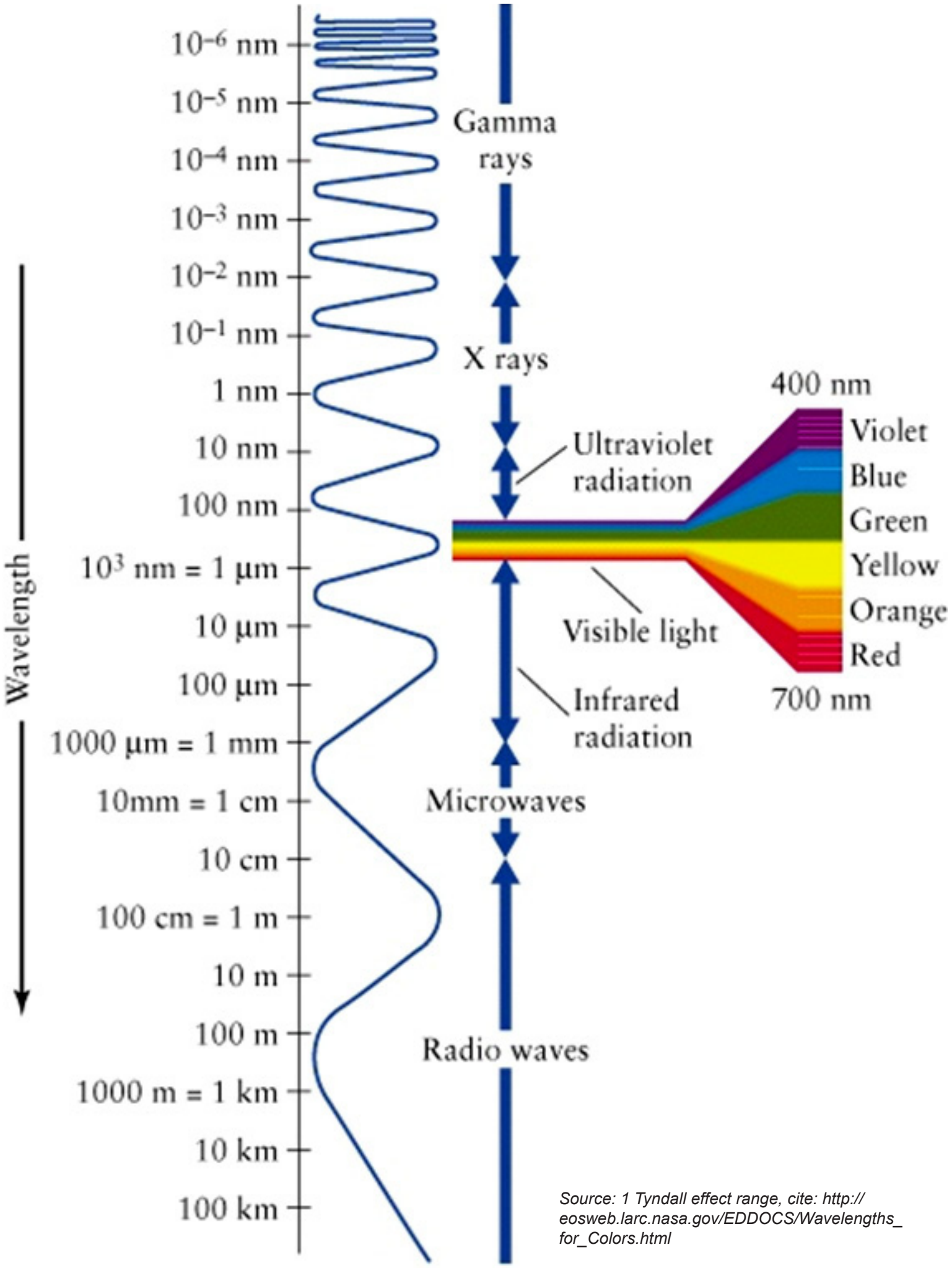
Ultraviolet light in dermatology:
Wood's light was introduced in 1903 by Robert W. and is produced by a low-pressure mercury arc that emits ultraviolet radiation between 320 and 450 nm. Under UV exposure, both endogenous and exogenous chromophores fluoresce, enabling visual detection. Similar UV emission is produced by devices such as LEDs, fluorescent lamps, and blacklight blue bulbs. Wood's light is widely used in dermatology to diagnose bacterial and fungal infections, hypopigmented disorders, and metabolic conditions. UV imaging techniques include direct fluorescence visualization, UV fluorescence photography, and reflectance photography. More recently, ultraviolet-induced fluorescence dermoscopy (UVFD) has applied this technology within a dermoscope, showing promising results. Although blue light penetrates only superficial skin layers, it enhances contrast between melanin and blood, with fluorescence arising from endogenous substances (e.g., melanin, collagen, flavins, Nicotinamide Adenine Dinucleotide Phosphate (NADPH), tryptophan) and exogenous sources such as microbial metabolites or parasites (3,4).

Tyndall effect and melanin fluorescence:
Dermoscopy allows detection of melanin, which appears in different colours depending on its depth in the skin, ranging from jet black and brown to steel blue. These colour changes are explained by the Tyndall effect, where shorter blue wavelengths are scattered more than longer red wavelengths. Rayleigh scattering also plays a role, describing light scattering by chromophores much smaller than the wavelength, with no energy loss or wavelength change. Ultraviolet-induced fluorescence dermoscopy (UVFD) mainly highlights superficial melanin, which is larger and more uniform in the upper skin layers, aiding clearer pigment demarcation (Figure 1) (5).

Photodiagnosis:
Photodiagnosis is increasingly used to support differential diagnosis in dermatology (Figure 2). Ultraviolet wavelengths between 300 and 430 nm have shown particular clinical value, with near-visible ranges (380–400 nm and 380–430 nm) being absorbed by melanin and perceived as purple light. UVFD can also detect porphyrins around 400 nm within the Soret band. A wavelength of 405 nm is beneficial for visualising vascular structures, as it is strongly absorbed by both oxidised and deoxygenated haemoglobin and produces green fluorescence. Beyond diagnosis, fluorescence findings may aid prognosis, with protoporphyrin IX serving as an indicator of disease severity in conditions such as plaque psoriasis and acne vulgaris (3,6).

Advantages of UVFD over Wood's lamp:
This technique offers several practical advantages, including no requirement for a darkroom, equipment warm-up, or fixed working distance from the skin, with reduced need for eye protection. Imaging is less affected by external artefacts, and the device is portable, providing added magnification (Table 1). It improves physician confidence in identifying surgical sites and helps delineate areas treated with topical chemotherapeutic agents (i.e., fluorouracil 5% cream), which remain darker than surrounding healthy skin. It may also have potential as a screening tool for completely regressed tumours, such as primary cutaneous melanoma. However, significant gaps remain in the literature, highlighting the need for further research to better understand and validate this emerging modality (7).

Figure 1: Tyndall effect range



Source: 1 Tyndall effect range, cite: http://eosweb.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html

Table 1: differences between the woods lamp and UVFD:

Woods lamp	UVFD
Older larger tool	Newer, more precise and portable tool
Uses a mercury vapour bulb and a specific filter (barium silicate with nickel oxide) to emit UV-A light, primarily peaking at 365 nm	Incorporates LED UV sources directly into a handheld dermatoscope, often providing more focused light (ranging from 365 nm to 405 nm) and higher-quality imaging
Can be bulky	Highly portable or handheld
General fluorescence	High-detail visualization
Typically offers low magnification (often around 1.5x to 4x).	Uses high-quality optical lenses, providing superior magnification (often 10x or higher).
Offers broader, dimmer view of a larger area of skin	Allows for much higher resolution and clearer visualization of structures (such as fine scales and follicular patterns)
Needs dark room	Usable in normal light
Needs warming up 1-5 minutes, to ensure mercury arc lamp reaches stable peak wavelength	Immediate start as it uses high intensity LEDs
Fixed working distance	Not applicable
Inexpensive	Expensive
Needs specific eye protection for both patients and the clinicians to avoid conjunctiva and retina injury	Reduced need for eye protection/ risks as light is targeted which lessens scattering toward eyes
	Helps in delineating the borders
	Might aid in screening regressed tumours
	Unreliability in distinguishing between melanin and haemoglobin
	Pigmented facial keratin can be challenging to differentiate from angulated lines mimicking malignancy
	Certain uneven surfaces can be challengeable, on face like nose, ear etc, periareolar, anogenital and acral areas where dark sealed environment is inaccessible
	Reduces the need for biopsies

UV dermatoscope concept and fluorescence mechanism:

The electromagnetic spectrum spans a wide range of radiation classified by wavelength or frequency, from radio waves to gamma rays. Only visible light, between 400 and 700 nm, can be seen by the human eye, while ultraviolet light used in dermatology lies between 10 and 400 nm. When high-energy UV light strikes skin chromophores, it is re-emitted as lower-energy visible light, a process known as the Stokes shift. This occurs as excited electrons return to their ground state, releasing energy as fluorescence. UV dermatoscopes and videodermatoscopes mainly emit low-energy UVA (320–400 nm) or violet-blue sub-UV light (400–425 nm). UVB dermatoscopes are not used due to safety concerns and poor image quality from weaker reflective signals(6).

Sub-UV and UV dermatoscopy is based on five key interactions between radiation and the skin: reflection, penetration, absorption, scattering, and the Stokes shift. The Stokes shift explains how UV or sub-UV excitation of skin chromophores, such as melanin and haemoglobin, results in the emission of lower-energy, longer-wavelength visible light perceived as fluorescence (Figure 3). Keratins mainly reflect this radiation, while excited chromophores release the absorbed energy as visible photons. Although sub-UV and UVA radiation can pose potential risks to the skin and retina, their diagnostic value lies in the ability of short-wavelength UV light to generate visible fluorescence when it interacts with skin chromophores(6).

Wood's lamp has long been used to diagnose a wide range of skin conditions, including bacterial and fungal infections, pigmentary disorders, cutaneous porphyrias, and to help define tumour margins. Combining this technology with dermoscopy may therefore enhance conventional dermoscopic assessment. Recent studies highlight the value of ultraviolet-induced fluorescence dermoscopy (UVFD) in diagnosing and monitoring conditions such as scabies, vitiligo, alopecia, seborrhoeic keratoses, pityriasis versicolor, and melanoma(1,7).

For over a century, UV light, particularly through the Wood's lamp, has been a simple, portable, and effective diagnostic tool in dermatology, especially for pigmented disorders, infections, porphyria, and non-melanoma skin cancer. Dermoscopy, meanwhile, is now integral to the evaluation of both pigmented and non-pigmented tumours, as well as inflammatory and infectious dermatoses, by revealing morphological features not visible to the naked eye. In non-tumour conditions, dermoscopic findings mainly reflect histological changes such as vascular patterns, cellular infiltrates, and epidermal alterations, which require polarized light for optimal visualization. Compared with Wood's lamp, UVF dermoscopy offers the additional practical advantage of not requiring a darkened room(7).

Ultraviolet-induced fluorescence dermoscopy (UVFD) improves physician confidence in identifying surgical sites compared with conventional polarized dermoscopy. Since UVFD is limited to superficial skin layers, it is particularly useful for distinguishing surface-confined neoplastic features, aiding clearer margin assessment, and potentially improving surgical outcomes(1,7).

Safety Concerns of UV Dermatoscopy

Photo-biological safety is an important consideration for light-emitting devices such as dermatoscopes. These devices are classified into four risk groups, from R0 (no risk) to R3 (high risk). The D'z-D100 Casio sUVRD dermocamera is classified as R0, while DermLite DL5 using UVFD is classed as R1 (low risk); safety data for other devices remain limited. Although UVA has carcinogenic potential, the UVA intensity of the DL5 is comparable to nail UV lamps, making the brief exposures used in UVFD clinically negligible. However, regulatory guidance recommends limiting UV exposure, particularly in individuals taking photosensitising medications.

UVA does not cause sunburn but may contribute to photosensitivity reactions, and both sub-UV and UVA can pose potential risks to the skin and retina. The R1 classification of the DL5 is mainly due to blue-light hazard, as UV filters reduce reflected UVA but have little effect on sub-UV emission. Standard sunscreens do not protect against blue light. While the theoretical maximum safe eye exposure for an R1 device is long and unlikely to be reached in practice, chronic occupational exposure may justify optional eye protection for clinicians and cataract prevention (Figure 1). Polycarbonate UV-protective glasses can further reduce risk, though blue-blocking lenses impair colour perception and lack strong evidence for preventing eye disease, including age-related macular degeneration. During examinations, patients, especially children, should close their eyes or use protective goggles, and the use of digital imaging can further minimise direct eye exposure(4,7).

Figure 2: The principle of UV fluorescence dermoscopy, Sivakumar et al 2025

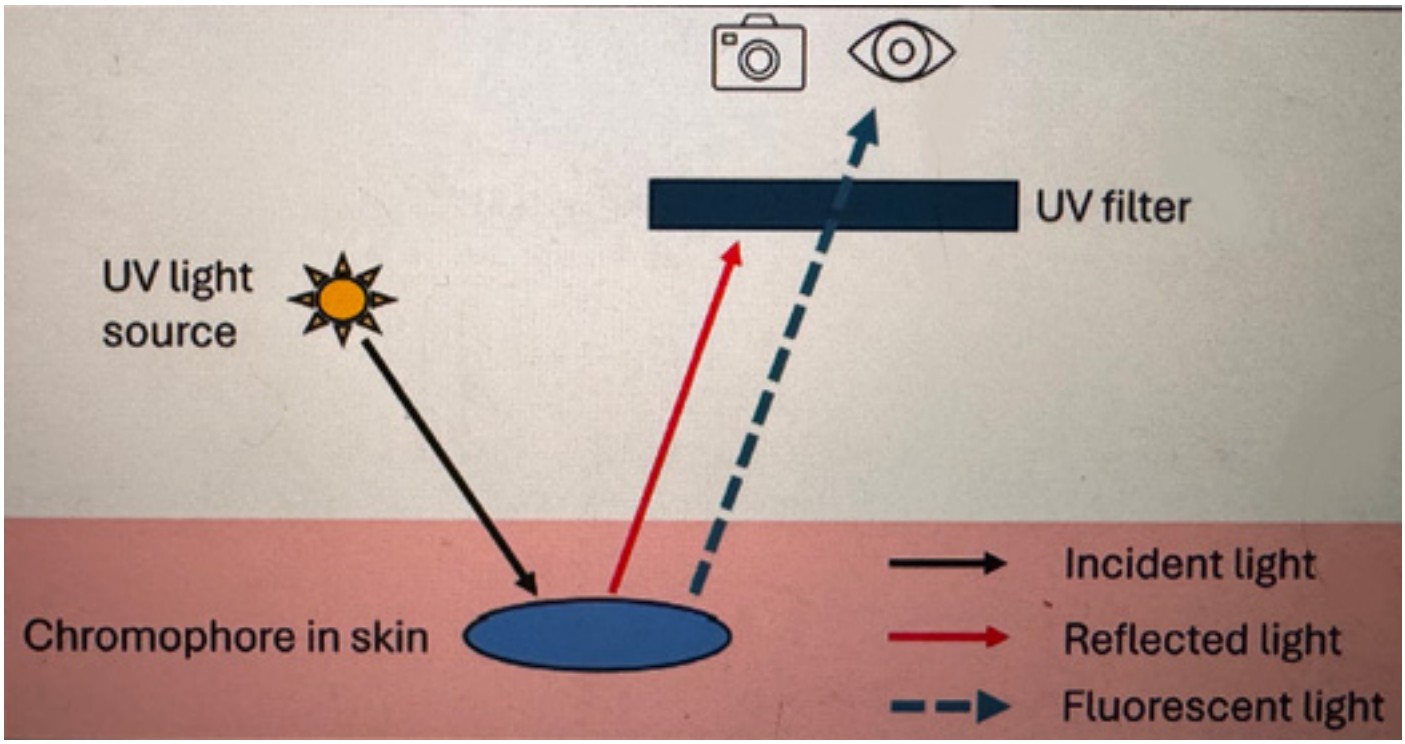
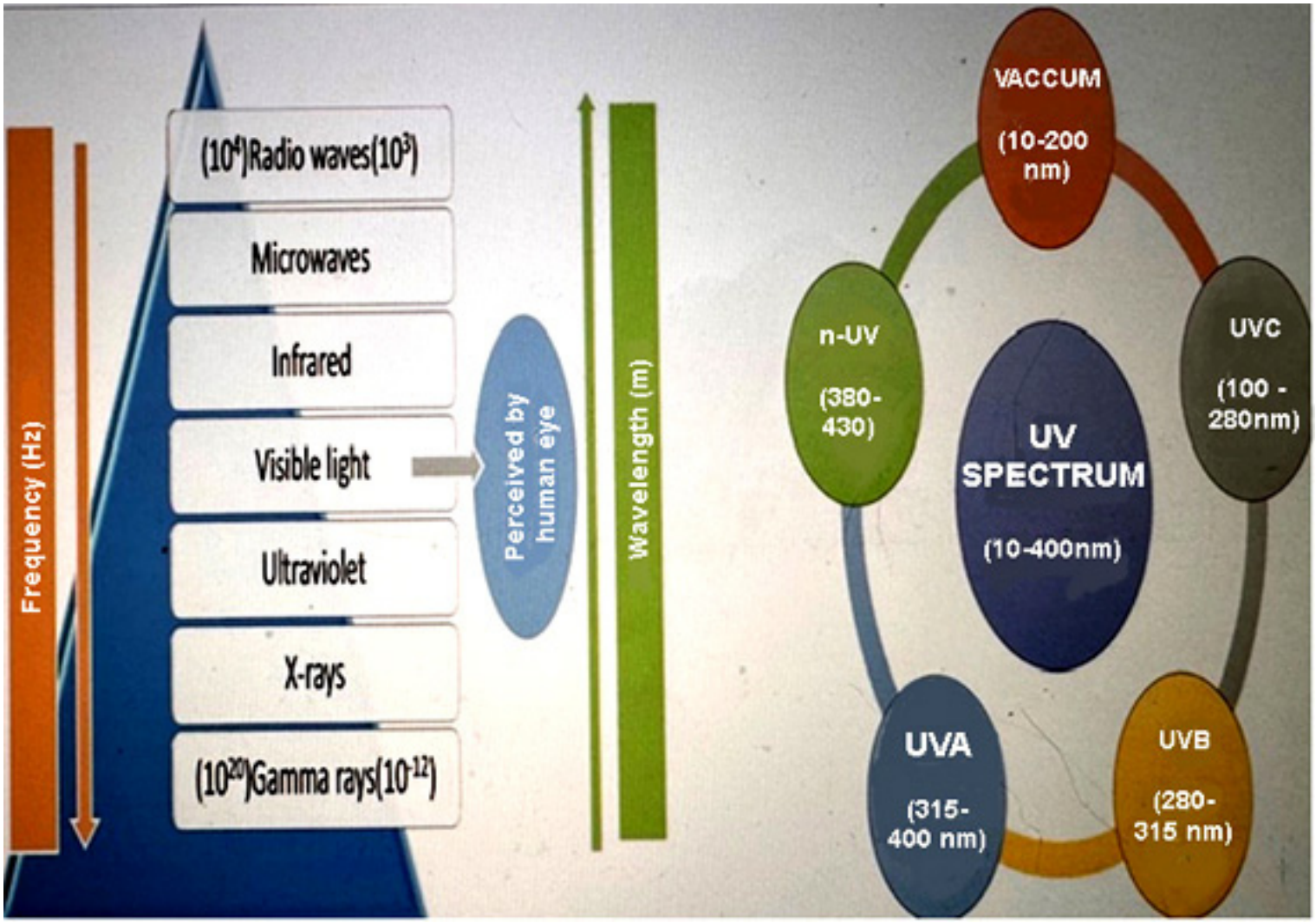


Figure 3: Tyndall phenomena., Bhat YJ et al, 2025



Factors and Limitations of UVFD, sUVRD, and UVRD dermatoscopy:

UV and sub-UV dermatoscopy have numerous significant limitations. A key issue is the difficulty in reliably distinguishing melanin from hemoglobin, especially for non-vascular pigmented structures, which may lead to misinterpretation. Pigmented scales can also mimic malignant clues, so these techniques must always be used alongside conventional dermatoscopy.

Chronic sun damage can interfere with absorption, reflection, and fluorescence patterns, reducing diagnostic accuracy. Excessive pressure during examination may eliminate vascular signals, similar to standard dermatoscopy(6).

Image quality is device-dependent; small wavelength differences and software-driven exposure or white-balance adjustments can significantly alter fluorescence intensity and colour. Uneven irregular skin surfaces (like, on the face, periareolar, anogenital, and acral regions, the dorsum of the nose, ears, and internal canthus) and hair make imaging difficult, particularly in facial and special sites, due to poor contact and light leakage, due to the difficulty of achieving proper contact plate adherence. Also, excessive pressure can cause central pallor due to loss of vascular supply to the structure. Contact and non-contact modes each have compromises, and no ideal contact medium has yet been established.

Patient preparation is critical. Sunscreens, cosmetics, topical or systemic drugs, and various substances can cause artificial fluorescence or signal loss, even if used days earlier. Excessive washing may remove fluorescent chromophores, while recent sun exposure can “burn out” fluorescence signals(10-13).

Fluorescence findings also vary with age, body site, bacterial colonisation, and skin of colour, where increased melanin absorption can reduce visibility of diagnostic clues.

Conclusions

UV dermatoscope has been used as a complementary assessment to polarized dermoscopy to diagnose dermatoses, including bacterial and fungal infections, pigmentary disorders, and skin neoplasms, showing a significant improvement in terms of diagnostic performance, including neoplastic, infectious, and inflammatory dermatoses. Also, it can help in differentiating alopecia, scarring and non-scarring, as its dermoscopic setting is more accurate to highlight both follicular openings and fibrotic areas(10,14).

UV dermoscopy is a valuable adjunctive tool across infectious, inflammatory, pigmentary, and neoplastic dermatoses. Its strength lies in revealing hidden contrast and fluorescence, of note, and it should be used alongside conventional polarized light-based dermoscopy, with awareness of its artefacts and limitations to increase diagnostic performance, and to avoid misinterpretation(14).

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