OPTICAL INSTRUMENTS

Lecture 7–

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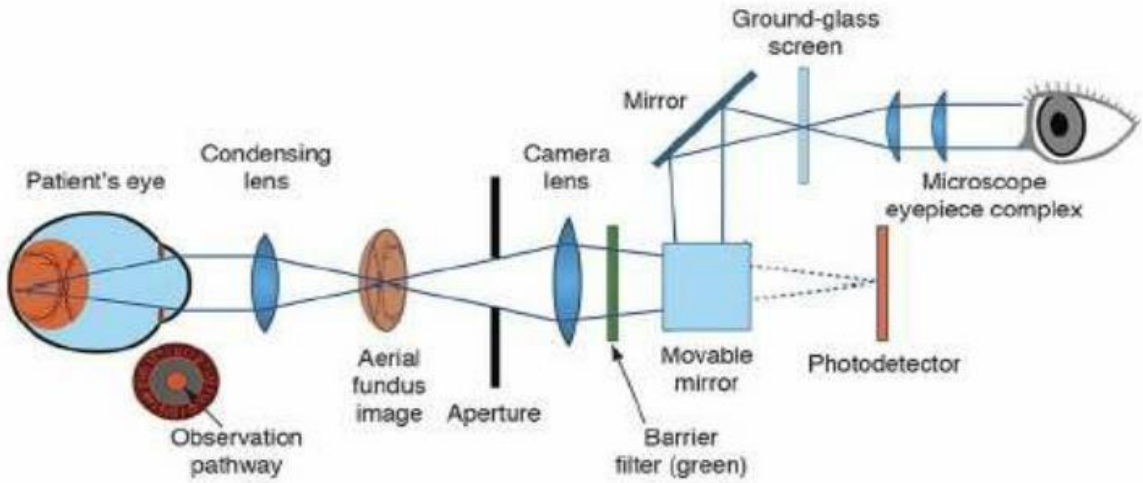
Fundus Camera

Fundus camera: is an optical device which consists of a specialized low power microscope with an attached camera used to take photographs of the fundus of the eye (retina).

Usage:

It is used to take fundus photographs to diagnose and monitor the progression of retinal diseases such as diabetic retinopathy and used also in fundus fluorescein angiography (inject fluorescein dye intravenously and take fundus camera to study the retinal blood vessels)



Optical principle

The optical principle of fundus camera is based on monocular indirect ophthalmoscopy in which the aerial image is reimaged onto a camera. A fundus camera provides an upright, magnified view of the fundus.

A typical fundus camera views 30-50 degrees of the retina with a magnification of 2.5x.

However, this field of view can be modified with the help of auxiliary lenses from 15 degrees with 5x magnification to 140 degrees with a wide angle lens which also minifies the images.

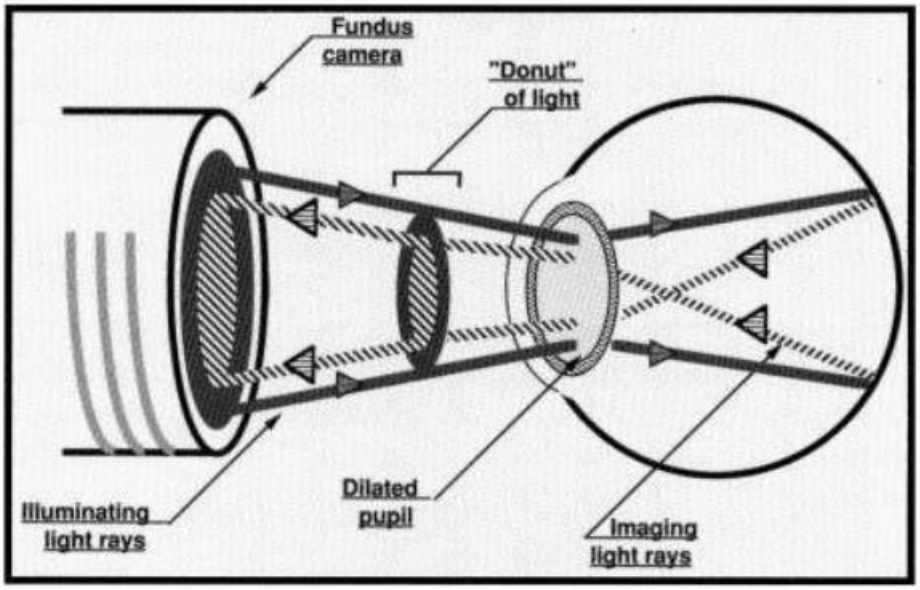
The optics of fundus camera are similar to that of indirect ophthalmoscope in which the illumination and observation systems follow dissimilar paths.

The beam paths of both systems are merged by a **pinhole mirror** and pass through objective lens as well as the patient's eye. Here the objective lens plays the same role as the ophthalmoscopy lens of the indirect opthahlmoscope.

1. **Illumination beam path**

To get good quality and reflection-free images, a **geometric pupil separation** is required. It means that the illumination and observation beam paths must be separated.

The illumination light is focused by a series of lenses through a donut shaped aperture. So that the patient's pupil is illuminated with a ring illumination and then this light illuminates the retina, while the reflected light from the retina passes through the pupil center where the optical imaging quality of the eye is highest. Because the light path of the two systems is separated, there is little reflection in the photographed image.



2. **Observation beam path**

The objective lens forms a real intermediate image of the illuminated fundus in front of the pinhole mirror. Behind the pinhole mirror, a second intermediate image is formed by the main objective lens. With a movable focusing lens, the rays are then parallelized (focus at infintity). In this way we get a flexible optical interface which can be used to attach:

- High resolution cameras for image acquisition
- Observer camera e.g. infrared CCDs for adjustment purposes

3. **Aperture stop**

Which defines the diameter of the exit pupil of the observation beam path and thus the optical resolution of the fundus image.

Once the image is captured, it is transferred to a PC to visualize the fundus and check the ocular condition.

Applications (modes of examination)

Fundus camera can perform the following modes of examination:

1. **Colour photography**, where the retina is illuminated by white light and examined

   in full colour.

2. **Red-free photography**, where red colour is filtered from the imaging light by using

   a green filter to improve contrast of blood vessels and hemorrhages

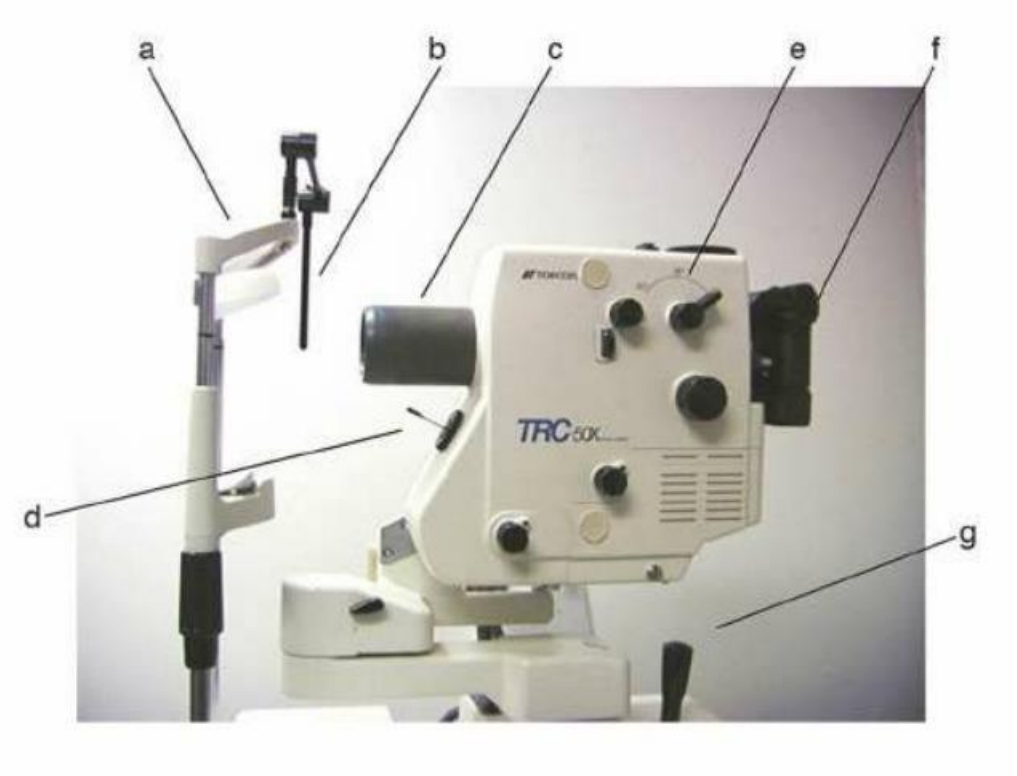
3. **Angiography**, where a special dye is injected intravenously and the retina is illuminated with an excitation colour which fluoresces light of another colour where the dye is present. A very high contrast image of retinal vessels is produced by filtering (exclusion) of excitation colour and passage of fluorescent colour.

Blood flow in retinal blood vessels can be observed by taking several photos at different time intervals.

Examples include fluoerescein angiography (FA) and indocyanine green angiography (ICG).

Simultaneous stereo fundus photos

Here the fundus is photographed from a slightly different angles at the same time. These two images are used together to create a 3D image which give better image about the retina. It can be used to image the optic disc in patients with glaucoma.



Parts of fundus camera:

Photograph of a fundus and fluorescein angiography camera showing patient forehead rest (a), fixation light (b), objective lens (c), fixation pointer (d), magnification lever (e), camera housing and eyepiece (f), and joystick (g)