The visual field

- The extent of object space “visible” while the eye steadily fixates a target.
- The projection into object space of all parts of the retina responsive to the stimulus being used and not obstructed by facial anatomy.
Visual Threshold

- **Threshold** stimulus: The weakest test stimulus that is just visible in a particular location under the specific testing condition. Threshold varies across the visual field. Normally, it is lowest in the fovea and increases with eccentricity in all directions.
- **Suprathreshold** stimulus: test stimulus that is stronger (larger or brighter) than the threshold stimulus. Stimulus is visible to observer.
- **Infrathreshold** stimulus: test stimulus that is weaker (smaller or dimmer) than the threshold stimulus. Stimulus is not seen.

The “island of vision” or “hill of vision”

A three-dimensional representation of visual sensitivity. Altitude of hill (vertical direction) at any location represents the visual sensitivity at that location.

Hill of Vision

- The hill is highest where dim small objects of low contrast are visible.
- It is lower where an object must be made more intense or larger or higher contrast to be seen.
- The hill of vision can be represented as a contour map (isopter plot) or with a cross section through the hill (profile plot).
**Isopter**

- The line connecting all points in the visual field with the same threshold is called the isopter (for a given test spot).
- Isopters vary depending on characteristics of the test spot (size, brightness etc.).
- The stimulus cannot be seen anywhere outside the isopter (the stimulus is infrathreshold outside the isopter).
- The stimulus can be seen anywhere inside the isopter (the stimulus is suprathreshold inside the isopter).
- Therefore, the isopter is a boundary between a region of visibility and invisibility for a particular stimulus.

**Visual Fields**

Perimetry: Testing Visual Threshold across the field

Perimetry originally referred to measurement of the edges, or perimeter, of the visual field. In modern usage, it means measuring visual sensitivity all over the visual field. Two main approaches have been used for perimetry:

1. Kinetic (Goldmann) Threshold Perimetry
2. Static Threshold Perimetry

**Kinetic Perimetry**

- Measuring the isopter for a given stimulus by moving the stimulus from an area where it is not seen toward an area where it is seen.
- Threshold: the location where the stimulus just becomes visible.
- Repeat at different locations in the visual field, connect the thresholds — isopter (for the given stimulus).
- The exact location of the kinetic isopter for a stimulus depends on the rate of movement of the stimulus.
Static Perimetry

- Visual threshold is measured at a series of fixed points in the visual field.
- The brightness of the test spot is varied, but not its location.
- Threshold is usually plotted relative to normal fields, to reveal defects.

Procedure in Static Perimetry

- Test spot: a projected spot of white light of a selected size and intensity on a background of a certain standard intensity.
- The size of the spot and the background illumination are kept constant throughout testing.
- The dimmest stimulus that can be seen is determined (by presenting the test spot at various intensities above the background illumination).
- Threshold: the weakest (dimmest) white spot that is visible against the background.
Factors Affecting Visual Field Measurement

- Size of the stimulus (test spot): a larger spot of fixed intensity is easier to see. Kinetic perimetry uses a series of fixed size spots to generate various isopters.
- Background illumination: Standard perimetry is an increment threshold task, so background illumination influences detectability according to Weber’s law for most backgrounds.
- Fixation accuracy: the eye must fixate the central point for the retinal locations to be accurate!
- Binocular suppression: Testing is usually done with an eye patch over the untested eye, and in some subjects this can generate binocular rivalry and suppression.
- Other factors: color of spot, movement/speed of spot, duration of spot, refractive status of the eye.

Modern Field Measurement

Visual field measurement has as its primary goal the early detection of field loss due to ganglion cell death in glaucoma. Early detection with perimetry is difficult because a loss of half the ganglion cells produces a relatively small change in sensitivity. Recent modifications to static automated perimetry use more sophisticated stimuli, designed to stimulate only a small fraction of the ganglion cells. The idea is that this will make losses more obvious.

Some newer methods are listed in the next slide. None is dramatically better than the standard automated perimetry using white spots on a white background.

Some recent “advances” in perimetry technology

The current popular method is Standard Automated Perimetry (SAP)
Some alternatives are:
- Short Wavelength Automated Perimetry (SWAP) - Blue on Yellow for S cones
- Frequency Doubling Technology (FDT) perimetry - flickering gratings targets
- High-pass resolution perimetry - Uses thin rings instead of spots
- Flicker Perimetry - Flickering targets instead of static flashes
- Aulhorn’s Snow field campimetry - Uses TV “snow” and pointing
- Motion perimetry - Detect moving targets instead of flashed ones
- Rarebit perimetry- uses very small, bright spots
- Pupil Perimetry - measures pupil responses instead of subject reports
- Multifocal VEP - measures cortical evoked potentials instead of subject reports

These Venn diagrams show the lack of agreement between the three methods in labeling a patient as “progressing” in glaucoma.

Retinal Distribution of S Cones

There are no S cones in the center of the fovea, and they are relatively sparse throughout the retina. Ganglion cells that compare S cones to L and M cones carry a “Blue/Yellow” signal, and are also relatively sparse. “Blue / Yellow perimetry” is designed to stimulate just this small percentage of ganglion cells to make a loss of cells more obvious.
By convention, the adapting luminance used with the Goldmann perimeter is 31.5 asb (10 candelas/m²).

The extent of spatial summation varies with eccentricity, consequently, the sensitivity profile changes with stimulus size. The “peak” of the hill of vision only shows up with small spots. Note that the two plots have opposite vertical scales.

Critical duration varies with size, eccentricity, and background luminance. The larger the stimulus &/or the higher the background luminance, the shorter the critical duration. Note the above plots are for foveal fixation; the critical duration increases with eccentricity.