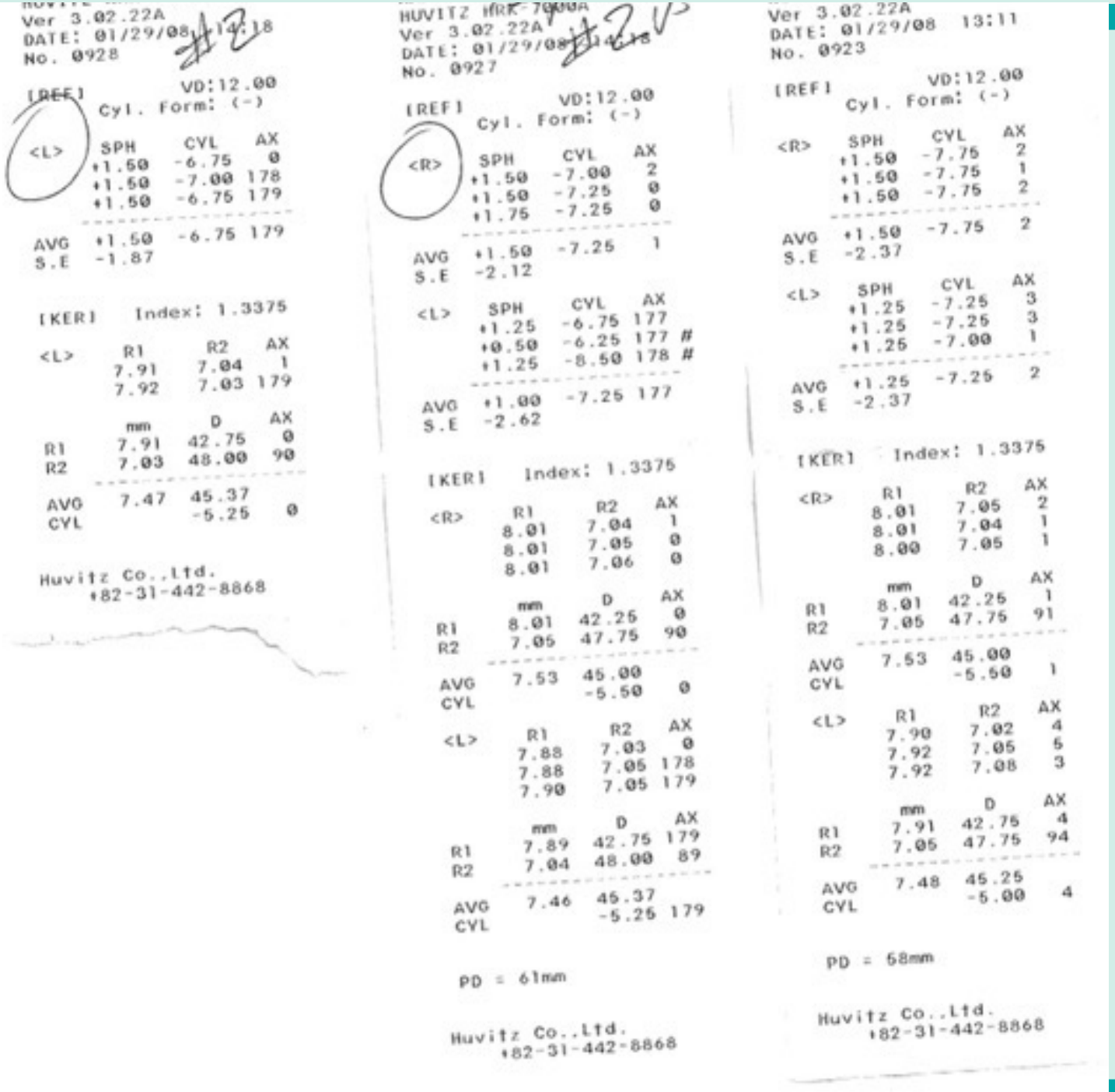

Ver 3.02.22A
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No. 0928

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	+1.50	-6.75	0
	+1.50	-7.00	178
	+1.50	-6.75	179
AVG	+1.50	-6.75	179
S.E	-1.87		

[KER] Index: 1.3375

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	R1	R2	AX
	7.91	7.04	1
	7.92	7.03	179

	mm	D	AX
R1	7.91	42.75	0
R2	7.03	48.00	90
AVG	7.47	45.37	
CYL		-5.25	0

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HUVITZ HRK-7000A
Ver 3.02.22A
DATE: 01/29/08 14:18
No. 0927

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	+1.50	-7.25	0
	+1.75	-7.25	0
AVG	+1.50	-7.25	1
S.E	-2.12		

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	SPH	CYL	AX	
	+1.25	-6.75	177	
	+0.50	-6.25	177	#
	+1.25	-8.50	178	#
AVG	+1.00	-7.25	177	
S.E	-2.62			

[KER] Index: 1.3375

<R>

	R1	R2	AX
	8.01	7.04	1
	8.01	7.05	0
	8.01	7.06	0

	mm	D	AX
R1	8.01	42.25	0
R2	7.05	47.75	90
AVG	7.53	45.00	
CYL		-5.50	0

<L>

	R1	R2	AX
	7.88	7.03	0
	7.88	7.05	178
	7.90	7.05	179

	mm	D	AX
R1	7.89	42.75	179
R2	7.04	48.00	89
AVG	7.46	45.37	
CYL		-5.25	179

PD = 61mm

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Ver 3.02.22A
DATE: 01/29/08 13:11
No. 0923

[REF] VD:12.00
Cyl. Form: (-)

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	+1.50	-7.75	1
	+1.50	-7.75	2
AVG	+1.50	-7.75	2
S.E	-2.37		

<L>

	SPH	CYL	AX
	+1.25	-7.25	3
	+1.25	-7.25	3
	+1.25	-7.00	1
AVG	+1.25	-7.25	2
S.E	-2.37		

[KER] Index: 1.3375

<R>

	R1	R2	AX
	8.01	7.05	2
	8.01	7.04	1
	8.00	7.05	1

	mm	D	AX
R1	8.01	42.25	1
R2	7.05	47.75	91
AVG	7.53	45.00	
CYL		-5.50	1

<L>

	R1	R2	AX
	7.90	7.02	4
	7.92	7.05	5
	7.92	7.08	3

	mm	D	AX
R1	7.91	42.75	4
R2	7.05	47.75	94
AVG	7.48	45.25	
CYL		-5.00	4

PD = 58mm

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The Matthew Effect…

The **Matthew effect of accumulated advantage**, **Matthew principle**, or **Matthew effect** is the tendency of individuals to accrue social or economic success in proportion to their initial level of popularity, friends, wealth, etc. It is sometimes summarized by the adage "the rich get richer and the poor get poorer".[1][2] The term was coined by sociologists Robert K. Merton and Harriet Zuckerman[3] in 1968[4] and takes its name from the Parable of the Talents in the biblical Gospel of Matthew.

Physiological Optics: An Introduction to Human Sight and Vision

with Dr. Charles A. Boulet

Dr. Charles Boulet

- Practicing general and developmental optometrist (BSc, BEd, OD)
- Former sciences teacher, IT developer
- Author / educator / researcher
- Find Me:
  - VisionMechanic.net
  - YouTube: Vision Mechanic
  - drboulet.com

Next Steps

- *Visual Anatomy
- *Introduction to Pediatric Vision Assessment
- *Vision and Vestibular Function (Prism Discussion)
- Oculomotor Skills Assessment
- Introduction to Vision Rehabilitation

Flatlanders – Vision Blindness

Flatlanders – Vision Blindness

Overview of Program –

By the time you're done this course you'll be able to …

- Differentiate between the essential refractive conditions: nearsightedness, farsightedness, astigmatism, anisometropia, aniseikonia, presbyopia.
- Categorize a refractive state as helpful or unhelpful. Distinguish between minimal refractive errors and those that are significant or severe.
- Analyze the specific nature of each of the refractive states and their impacts on performance.
- For individual clients and in general, assess and describe how refractive states impact on human development and learning outcomes.
- Apply your knowledge and understanding to identify from simply observing whether someone is nearsighted, farsighted, or presbyopic.

Overview of Program –

By the time you're done this course you'll be able to …

- Read and assess auto-refractor strips to arise at science-based conclusions about your client's needs and behavior. Gain insight into those in your care, with an emphasis on child development and behaviour.
- Evaluate and assess one of the most commonly underdiagnosed impediments to learning and development – Refractive State.
- Investigate lens properties and recognize where some optical solutions may be better in some cases than in others.

I hope you enjoy this program – it's ideal for parents, teachers, family doctors, school staff, and psychologists. There's much more to come, starting with a quick primer on human vision. Other courses in this series present much more detailed information that you should pursue, but for now we'll undertake a simple quick review of things.

Overview of Program –

Science! But fear not.

- New terms will be described, explained – repeatedly. You can always rewind, repeat, and change the speed of playback as desired.
- ALL the notes will be included in the program handout.
- Demonstrations! This course has loads of demos and videos from 3rd party sources to visually explain concepts.
- What you learn will be immediately relevant and applicable in the real world.
- Additional resources provided to continue study – links, texts, videos.
- Test Questions – You'll see flags appear from time to time to help you focus in on key constructs. The review at the end will ensure you are well-prepared to pass your test and put your new knowledge and skills into play.

Course Introduction

Let there be light…

Narration over images

Refraction

- Dictionary of Visual Science and Related Clinical Terms
  by Hoffstetter, et al. through Butterworth Heineman

The altering of the pathway of light from its original direction as a result of passing obliquely from one medium to another of different index of refraction.

The refractive and muscular state of the eyes, or the act or process of determining and/or correcting it.

At a high level, this program will explore…

How people receive light naturally (What it is like to have nearsight, farsight, astigmatism, and other conditions that we'll review.)

What our eyes do to try to accommodate for any lack of clarity.

How this affects us in daily life and in clinic.

What can and should be done about it, accounting for purpose and age.

A Vision Primer

Introduction

A Vision Primer

Adler's Physiology of the Eye - Kaufman and Alm (Mosby, 2002),

Clinical Anatomy and Physiology of the Visual System, 3rd Ed. - Remington (Elsevier, 2012).

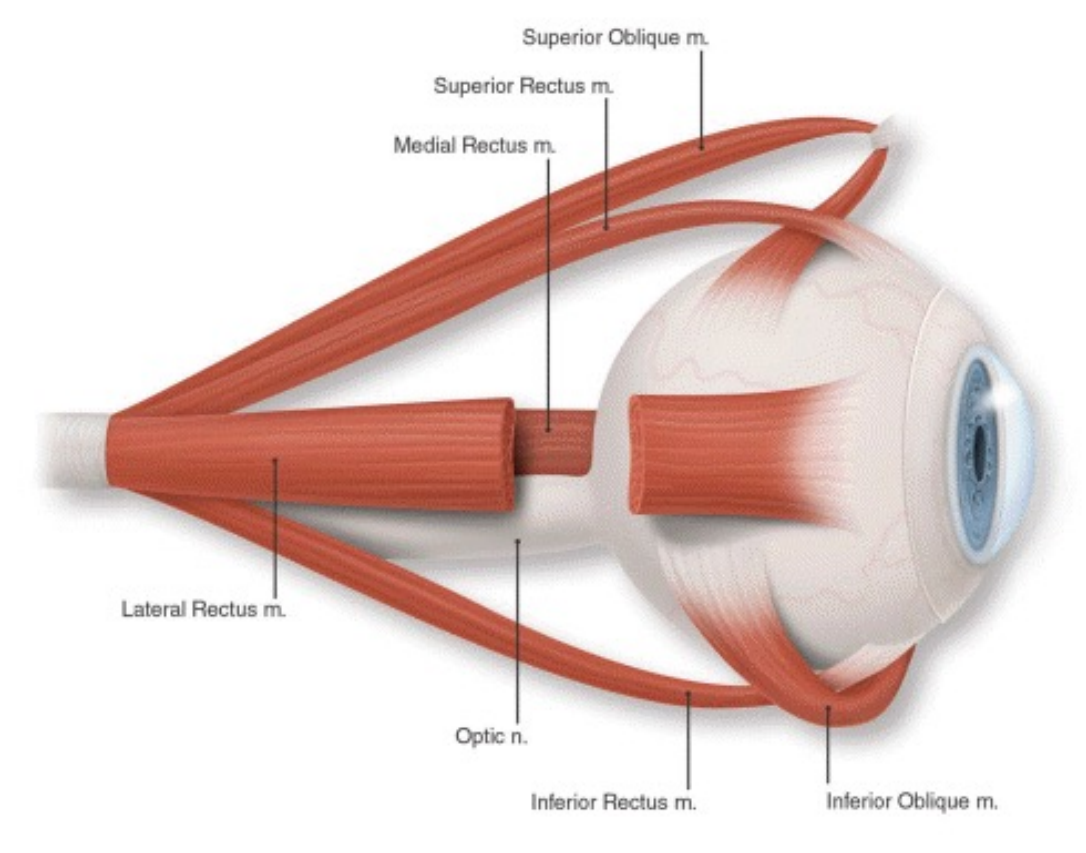
Basic Visual Anatomy

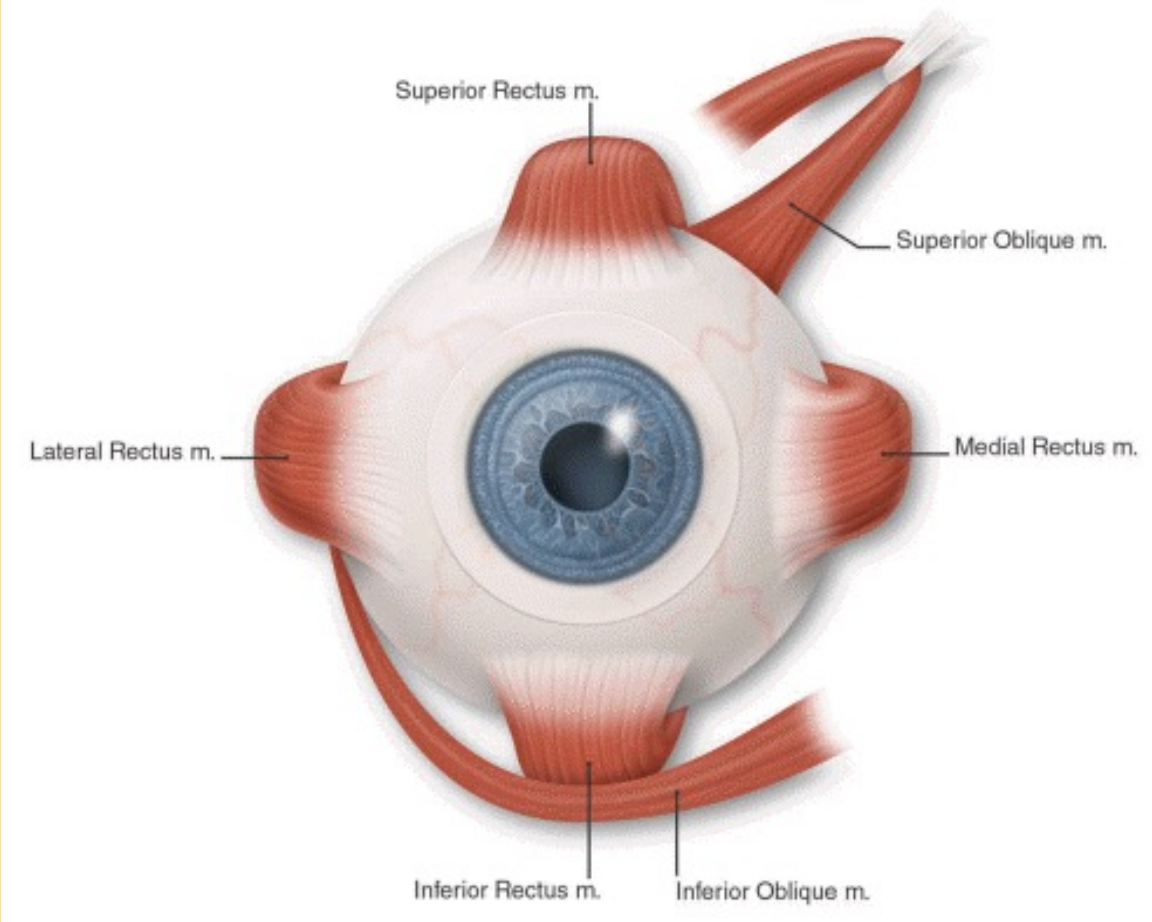
Video

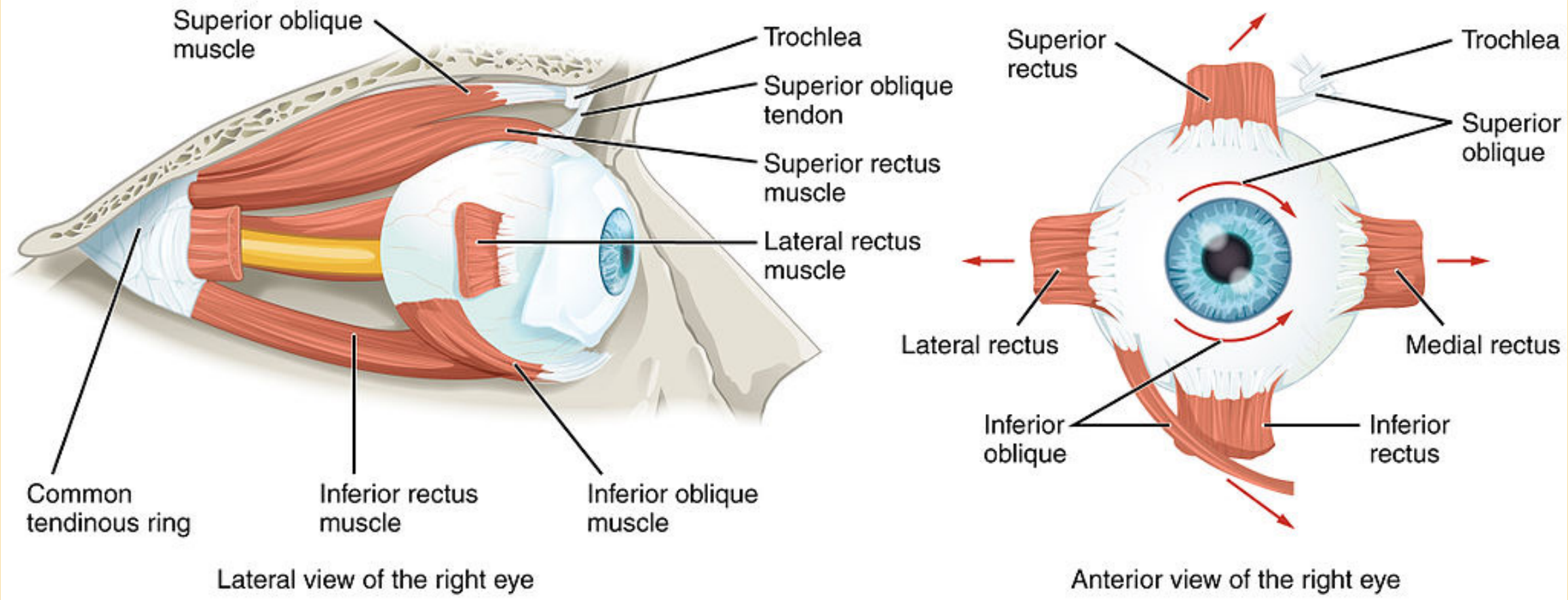
1_Intro to Ocular Anatomy Section

2_Eye Anatomy Intro

Each eye's movement is controlled by 6 muscles, the extraocular muscles.

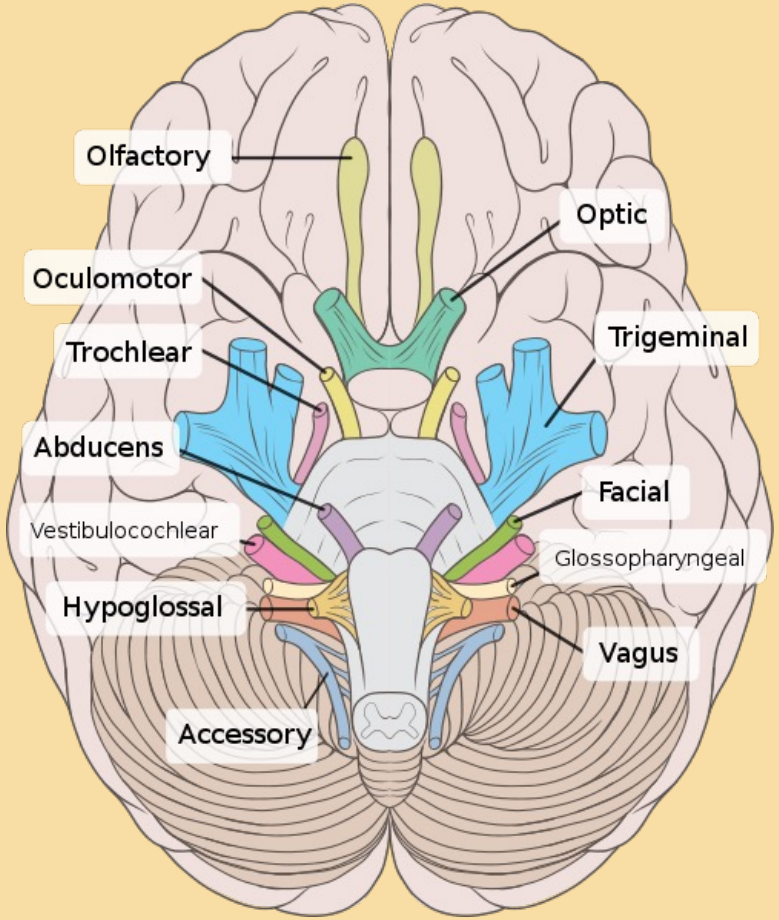






- Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

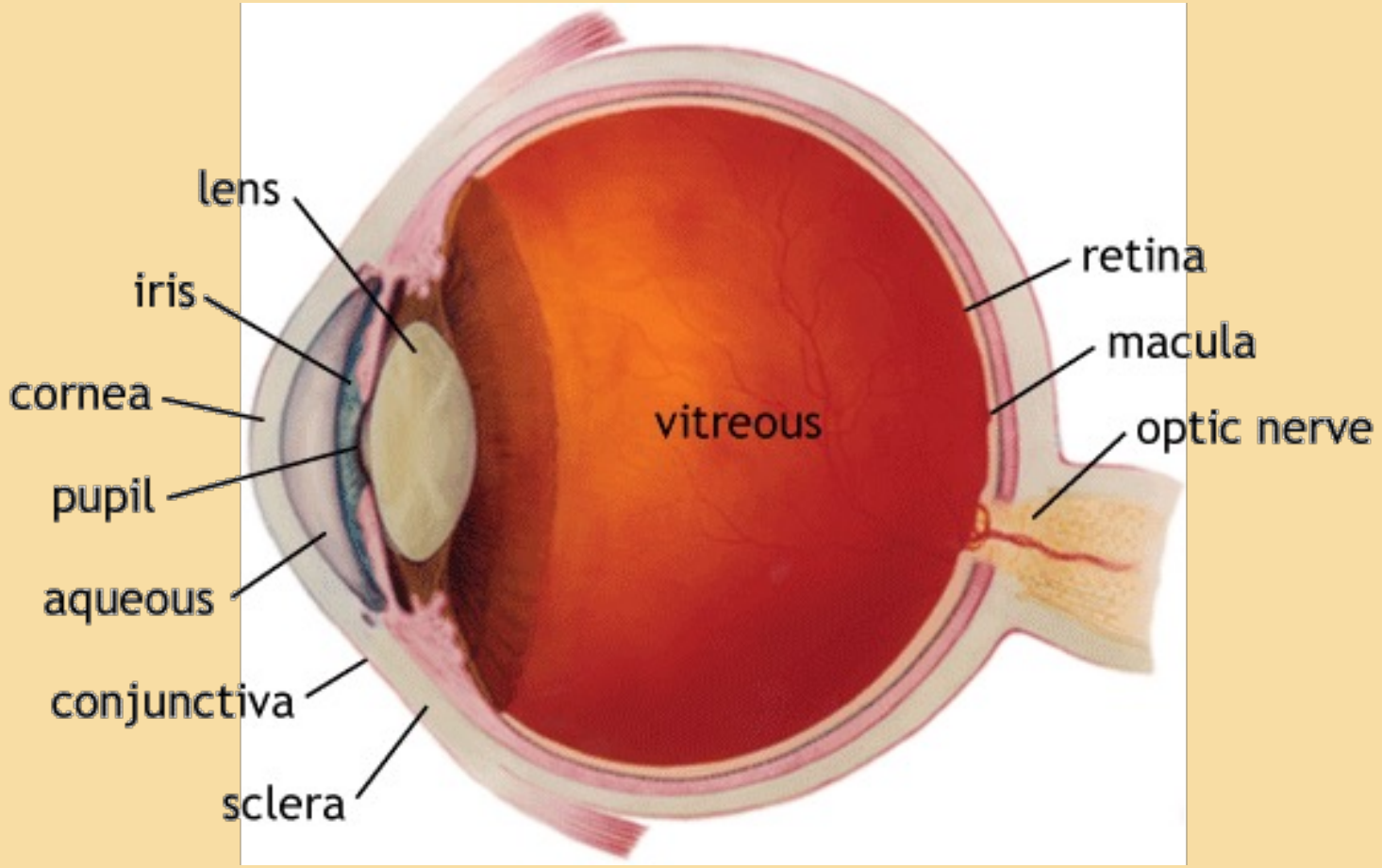
The eyes work independently of one another, but their movement is coordinated by different parts of the brain from brainstem to cortical areas.



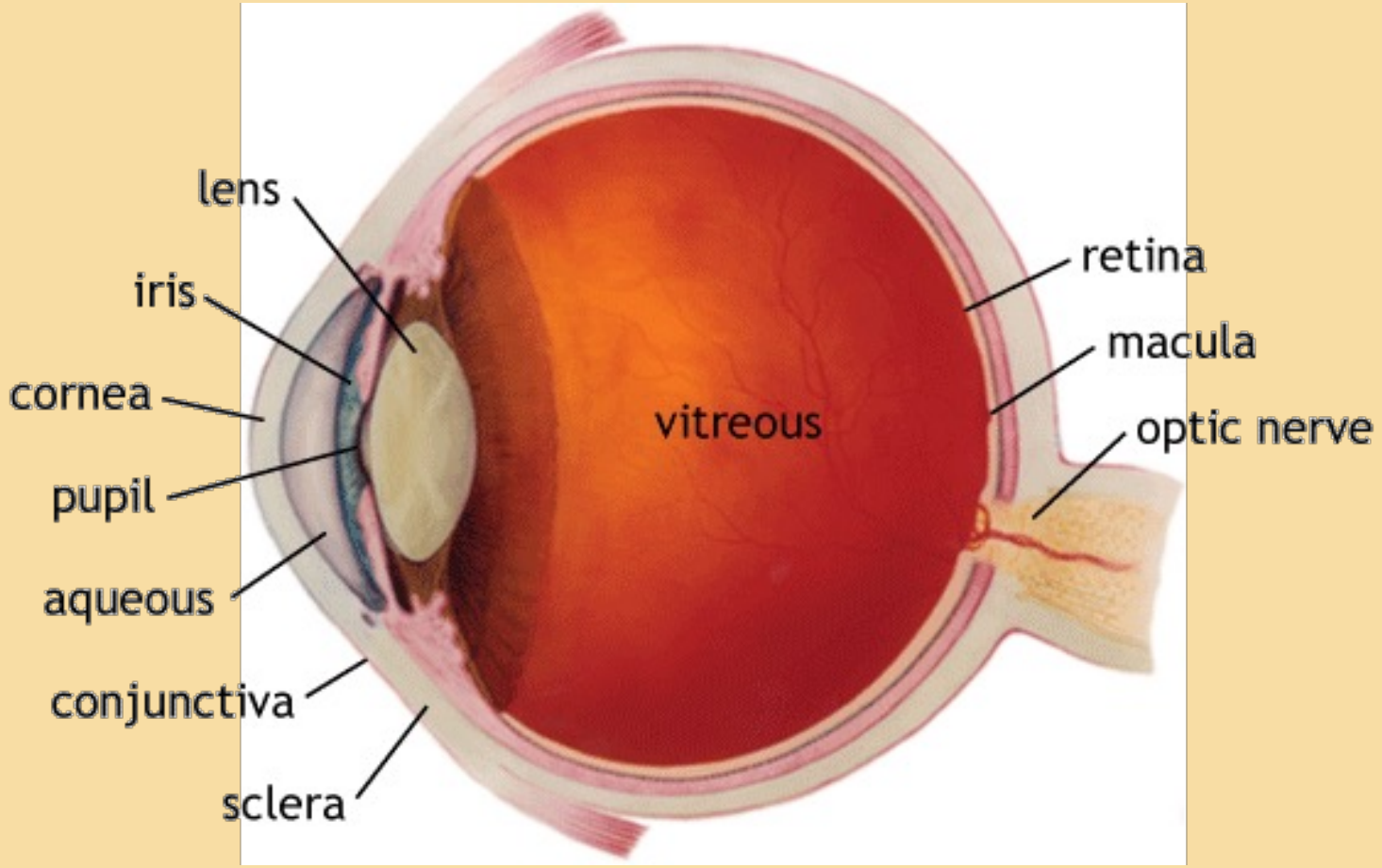
There are gross eye movements to quickly shift gaze or maintain gaze, and fine motor movements for very precise tracking of targets or moving quickly across text. Different movement types are controlled by different parts of the brain.

Inside the eye, there are the *intraocular* muscles, those muscles primarily concerned with controlling the size of the pupil, and another set that controls focus.

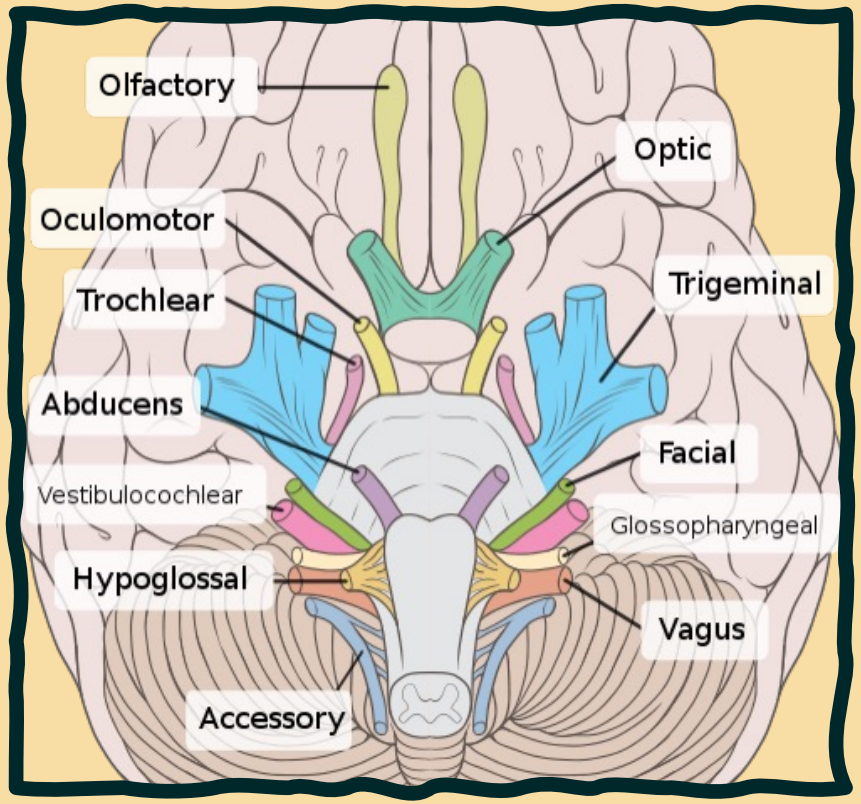
Each eye has an optic nerve that carries information to varied points in the brain, not just to the primary visual cortex.



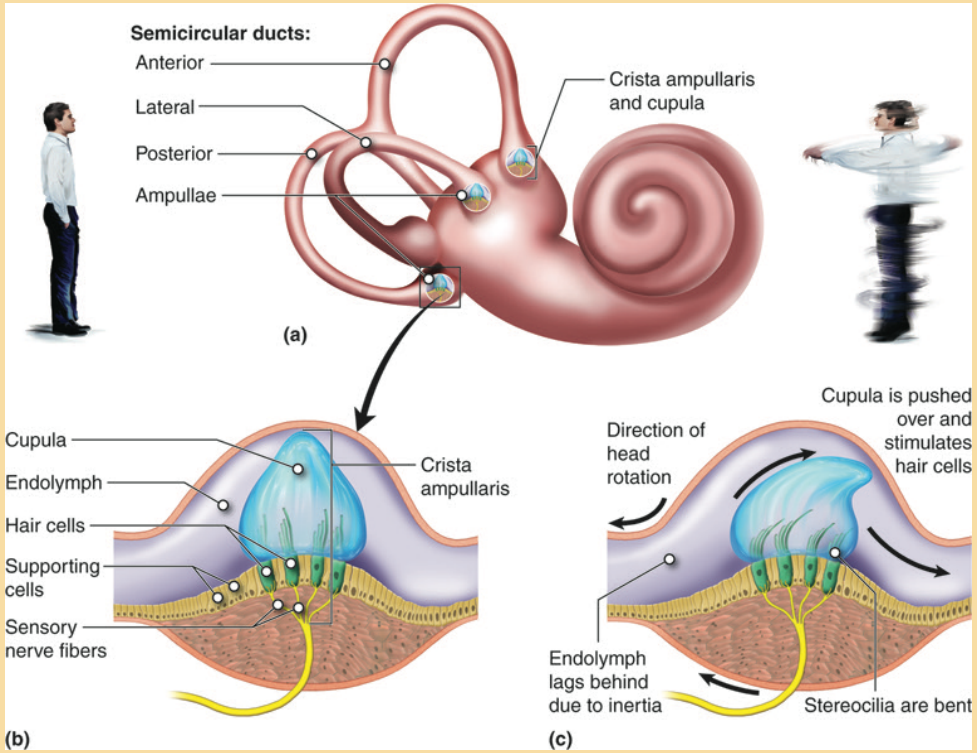
The retina, or the collection of light sensitive nerve fibers lining the inside of the eyes, is comprised of multiple layers of specialized cells.



Of the 12 cranial nerves (CN), 8 are somehow related to visual function, helping to integrate touch, sound, sight, balance, and muscle control. The optic nerve (CN II) is one of these, the others include: oculomotor (CN III), trochlear (CN IV), trigeminal (CN V), abducens (CN VI), facial (CN VII), vestibulocochlear aka auditory-vestibular (CN VIII), and the accessory nerve (CN XI).



- **Optic Nerve**: Also called Cranial Nerve II (CN II). It's interesting to note that when we look into the eye to observe the retina and optic nerve, we are actually observing live brain tissue in action!



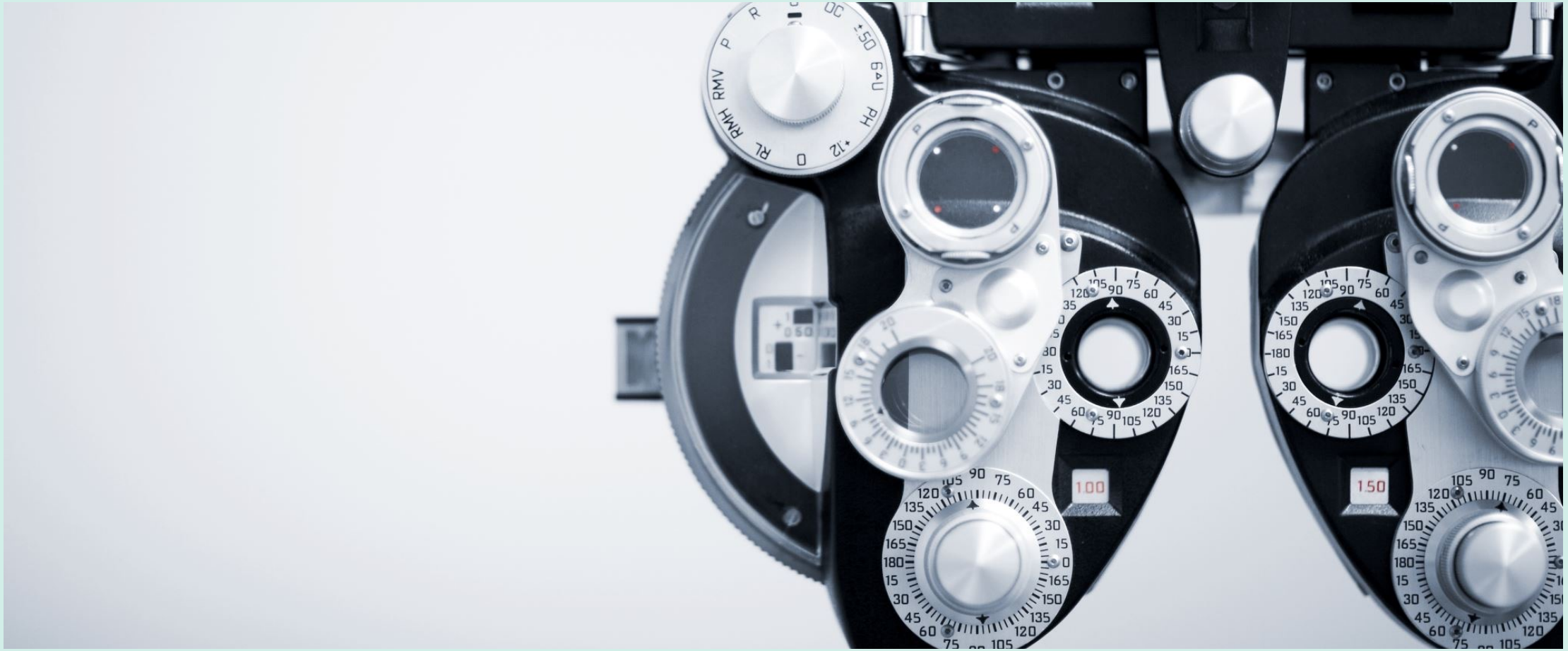
- **Dynamic Equilibrium**

- The **semicircular canals** are three ring-like extensions from the vestibule and are mostly responsible for dynamic equilibrium. One ring is oriented in the horizontal plane and two others are in the vertical plane. At the base of each semicircular canal, where it meets with the vestibule is an enlarged region known as the **ampulla**, which contains a hair-cell containing structure, called the **crista ampullaris**that responds to rotational movement. The stereocilia of the hair cells extend into the **cupula**, a membrane that attaches to the top of the ampulla (Fig. 8.44).

- When the head rotates in a plane parallel to the semicircular canal, the fluid in the canal does not move as quickly as the head is moving. This pushes the cupula in the opposite direction, deflecting the stereocilia and creating a nerve impulse. Considering the semicircular canals on either side of the head, three orthogonal planes are defined, the horizontal plane with both horizontal canals, and two vertical planes 90° to each other with the anterior canal from one side and the posterior canal from the other. In each pair, deflection of the cupula on one side of the body causes depolarization of the hair cells while the same movement causes hyperpolarization of the hair cells on the other side of the body. For example, when the head rotates to the right, the horizontal canals are active and the right side depolarizes while the left hyperpolarizes, indicating the direction of the movement. By comparing the relative movements of all six semicircular canals, the vestibular system can establish movement in any direction within three-dimensional space.

- ***Figure 8.44.*** *Structure and Function of the Semicircular Canals. The three canals each have an ampulla containing a crista ampullaris and cupula (a). When the head is stationary, the cupula, and embedded stereocilia, are not bent (b). When the head rotates in the same plane as one of the canals, the fluid in the canal (endolymph) lags, leading to bending of the stereocilia in the cupula, which initiates nerve impulses. This work by Cenveo is licensed under a Creative Commons Attribution 3.0 United States (http://creativecommons.org/licenses/by/3.0/us/).*

Elements of Vision



Skills that are required to target a visual signal of interest (that is, something we want to see). These are referred to as **Visual Signal Acquisition** (**VSA**) skills and consist of the mechanical side of vision.

Skills that are required for making sense of what it seen. These are mental behaviours best described as the computer software side to vision, and categorized as **Visual Signal Processing (VSP)**

Advanced behaviours that rely in large part upon visual input, such as cognition, balance, visual motor coordination, reading, gauging emotional responses, and others.

Visual Signal Acquisition – Finding What Is Important

Pursuits – smooth eye movements needed for tracking moving targets or balancing spatial awareness when the body moves or when objects move around the body.

Saccades – (suh-‘kawds or suh-‘kādes). ‘Jump’ eye movements. These can range from single long jumps, like from one scene to another on the complete opposite side of the visual field, to the rapid and automated very fine movements of fractions of millimeters such as are required for reading.

Vergence – The movement in opposing directions of the eyes such as occurs when looking near to far and back again – the eyes will go from a crossed position to a parallel position (divergence), then re-cross in order to see the near object (convergence).

Versions – These are movements of the eyes in the same direction, such as when then look up, down, left, right.

Fixation – The ability to maintain visual focus on a single object, keeping the eyes steady and on target.

Posture –When an eye is covered, it will move to its resting position, this is its posture. Given a target, most people's eyes will tend to want to naturally drift outwardly from a target (exophoria), or inwardly (esophoria).

Alignment – The eyes should be relatively balanced and symmetrical in their positioning. In the case of strabismus, one eye is misaligned when the other is on target.

Focus / Refractive State – The eyes will always try to maintain maximum clarity of an image.

Central vs Peripheral Awareness – These are the result of both internal brain functions, such as our internal mapping of external space, and the input of light from two parallel pathways that start in the retina: Central vision, involving the macula (the physical centre of the sensory tissue at the back of the eye where we perceive the greatest detail), and peripheral retina which comprises most of the light sensitive tissue by area and produces very poor visual acuity. Our attention switches from central to peripheral awareness both automatically, and when we tell it to.

Eyesight – the refractive, or resolving power of the eye to focus images. This is a matter of ‘bending’ and ‘straightening’ light so it can be focused onto the retina. The focusing system contributes only part of the focusing ability of the eye, the rest is static; it is the static part of the focusing power that is the source of most focusing problems. There are a great variety of refractive combinations that exist, and each has its own effect on vision and behaviour; for example, nearsightedness and farsightedness have decidedly different effects on near work. See the section on behavioural effects of vision to learn more.

Visual Signal Processing – Making Sense of What Is Seen

Visual Discrimination – The ability to distinguish differences between objects and scenes to tell if they are distinct from one another. In school, fine visual discrimination is especially relevant early when learning to distinguish letters and graphemes.

Visual Memory – Consists of not only accuracy of memory, but breadth (how much can be remembered), and duration.

Spatial Relationships – The ability to discriminate between relative positioning of objects, and the spatial relations between objects.

Form Constancy – The ability to recognize a visual signal (target) even when it is positioned or represented somewhat differently. When an apple appears to be an apple, even if it is turned upside down, or a letter ‘A’ is still an ‘A’ in a different font, or font size.

Sequential Memory – The ability to recall visual signals in a specific order.

Figure-Ground - Figure-ground is the ability to distinguish items of interest from a noisy background, like specific words on a pages full of text, or ‘Waldo’ in a crowd.)

Visual Closure – The ability to mentally complete a partially completed signal, such as when only a part of a face is visible in a photo, or when only a part of a word is visible.

Spatial Awareness – Our internal mapping and sense of where we are in the world, and where objects are positioned in space relative to ourselves.

Visualization – Somewhat related to central, peripheral, and spatial awareness, this is the ability to see in one's mind the world as it actually exists. This enables motor planning and anticipation.

Motor Planning –

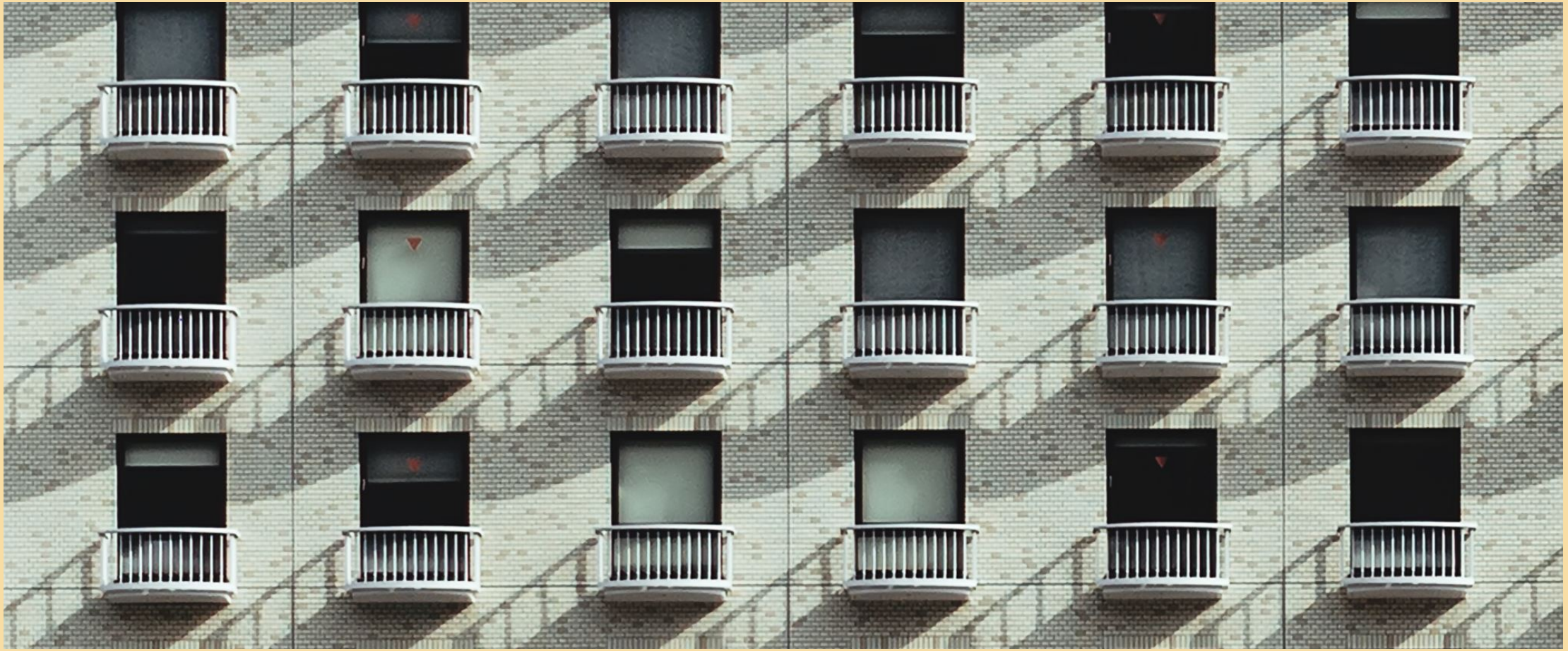
- Retinal / Ocular Positioning inputs (eyeball proprioception)
- Somatosensation esp. Proproprioception
- Vestibular (Balance)

Sensory Attention

Eyesight Vs. Vision — A Behavioural Perspective

Accommodation

(not THAT kind of accommodation, focus now…)



- Neutral Eyesight (*Emmetropia*)

- Nearsightedness (***myopia***)

- Farsightedness (***hyperopia***)

- Astigmatism

- Anisometropia

- Presbyopia

- Astigmatism induces a constant accommodative strain.
- Hyperopia requires a constant accommodative response
- Myopia requires that the eyes’ accommodative response relax for distance vision.

Myopia requires that the eyes' accommodative response relax for distance vision.

Given physiologic limitations of the eye, the ciliary body cannot release enough tension to provide sufficient defocusing to see clearly in the distance. That is, a muscle can only relax so much.

- **Nearer objects require an accommodative response as well as convergence of the eyes**
- Presbyopia diminishes accommodative amplitude.

Approaches to Measuring REFRACTION

The measured refractive state of the eye when accommodation is at rest, as by fixating a target at infinity, but not paralyzed.

The act or process of determining the refractive state of the eye when accommodation is at rest, as by fixating a target at infinity, but not paralyzed.

Cycloplegic Refraction (n): Refractive state of the eye when accommodation is totally or partially paralyzed by a cycloplegic (agent), typically something like tropicamide or cyclopentolate.

Cycloplegic Refraction (v): The process or act of determining the refractive state of the eye when accommodation is totally or partially paralyzed by a cycloplegic.

- Objective Refraction

Let’s talk about focusing and optics for a minute…

A target at 2m distance has a vergence demand of 1 / 2 diopters – we need to add a half diopter to sharpen the image, and that comes in the form of muscle effort to change the shape of the lens.

At 50cm or 20 inches, that’s 1 / 0.5 = 2D of focusing or accommodative effort to make the target clear once again.

At 12 inches, or 30cm, the focusing requirement is now 1 / 0.33 = 3D.

Finally, if you’re studying an object at 5cm, the accommodative demand is now 1 / 0.05 = 20D.

Quick Review – Refractive States

EMMETROPIA –Neutral Sightedness

- Eye is tuned naturally to view distant targets / signals with no significant accommodative effort.
- “Tuned” - The anterior segment has sufficient power and focusing range to focus the distant signal clearly on the neuroretina.

Myopia (Nearsightedness)

- Distant objects are blurred, but viewing distance causes only minimal discomfort, if any. Often the discomfort arises from facial muscle overexertion in the squint reflex. Near objects are seen with ease.
- Tuning: The anterior segment is over-focused, so too much plus power. This is often, but not always the result of the eye have grown too large.
- The distant image is focused in front of the retina and must be corrected with minus lenses to push the image backward onto the retina.

Hyperopia (Hypermetropia, Farsightedness)

- All targets at all distances will be blurred, but distant targets less so. Discomfort is common and worse with near targets and detailed targets as both the ocular muscles (ciliary body, pupillary constrictor/sphincter) and facial muscles struggle to render a clear image. The strain can lead to inward turning of the eyes, esotropia (recall Near Triad).
- Tuning: The anterior segment is under-focussed, so not enough plus power. This is often, but not always the result of the eye having not grown large enough.
- The distant image is focused behind the retina and must be corrected with plus lenses to push the image forward onto the retina.

Astigmatism (Cylinder, Toricity)

- Visual signals / targets are all blurred, all the time. There is a constant engaging and releasing of accommodation, and this leads to constant strain, made worse with viewing more detailed signals.
- Tuning: The eyes' optics have two focal planes, and the image is spread across these two in space. This may be in front of the retina, behind, or in front and behind.
- Toric lenses must be used to see clearly and comfortably at any distance.

Presbyopia (Old Eyes, Ageing Eyes)

- Affects all people in the same way but with different effects. Sometimes a problem, not always. But most people need a cheater every now and then, even just to write a cheque.
- With clear distance vision, near vision is gradually more challenged as the lens loses elasticity in time. (150 years ago, presbyopia was not much of an issue… lifespan and tasking.)
- Glasses / multifocals can be helpful to reduce the strain of balancing near and distance vision.

Anisometropia

- Significant difference of refractive state between the eyes. This can be **hyperopic**, **myopic**, **toric/astigmatic**, or ***antimetropic.***
- Most often leads to discomfort / asthenopia, but can be advantageous in some instances of presbyopia.
- Best corrected with contact lenses or ‘balanced’ iseikonic lenses.

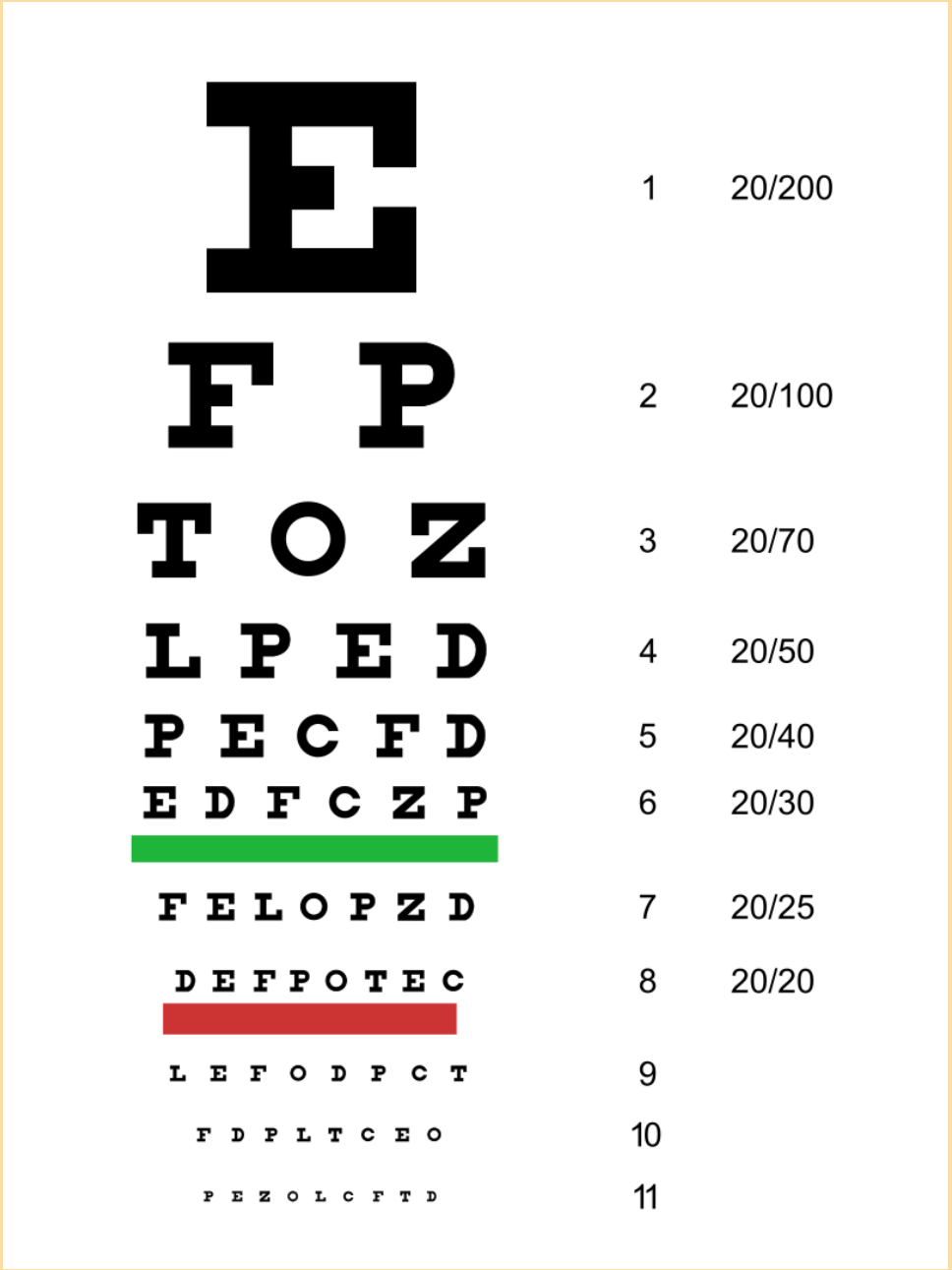
Aniseikonia

- Inter-ocular magnification difference, usually due to refractive state or correction of imbalance in refractive state.

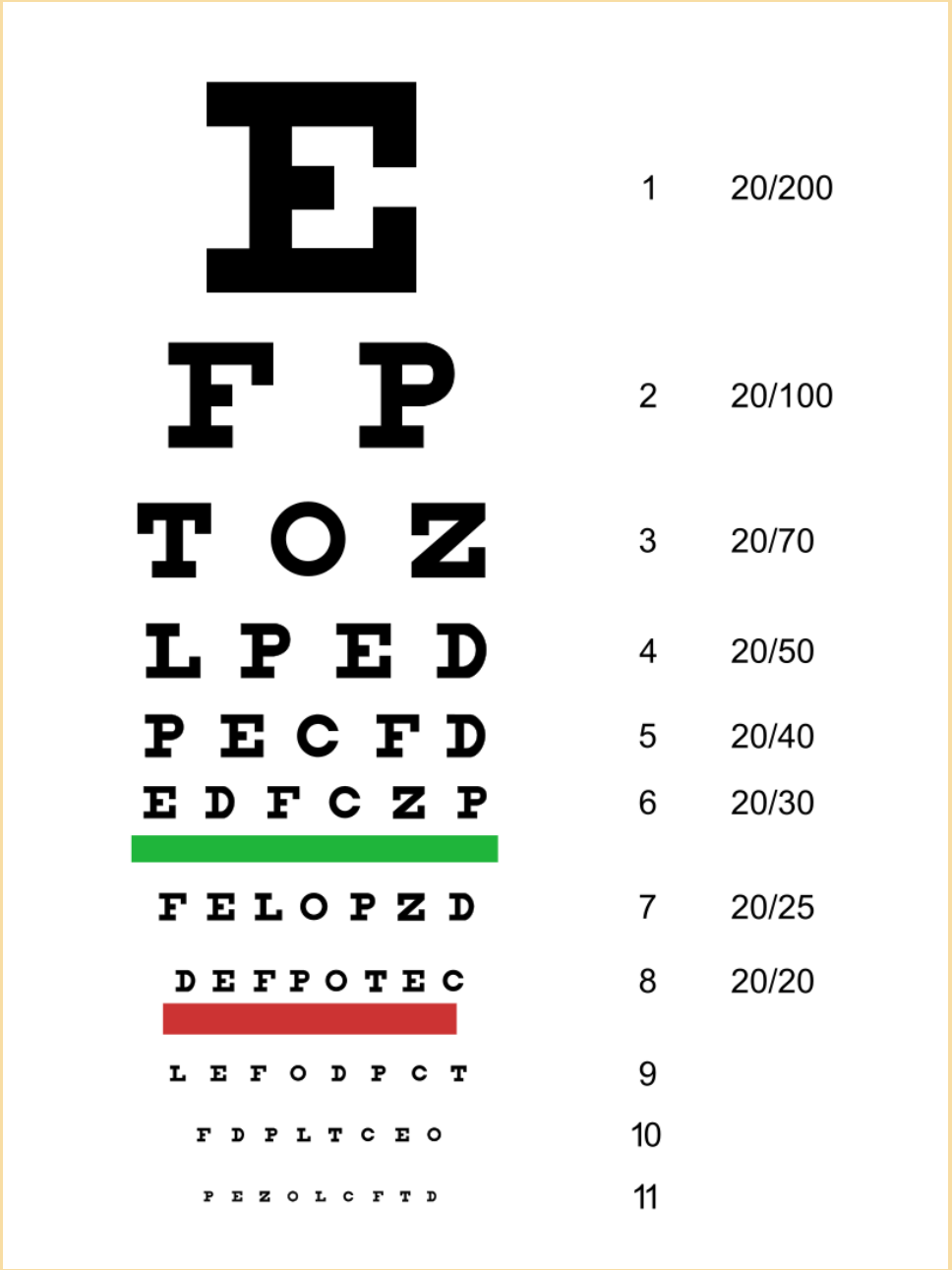
Glasses Prescriptions and Eye Charts

Eye Charts

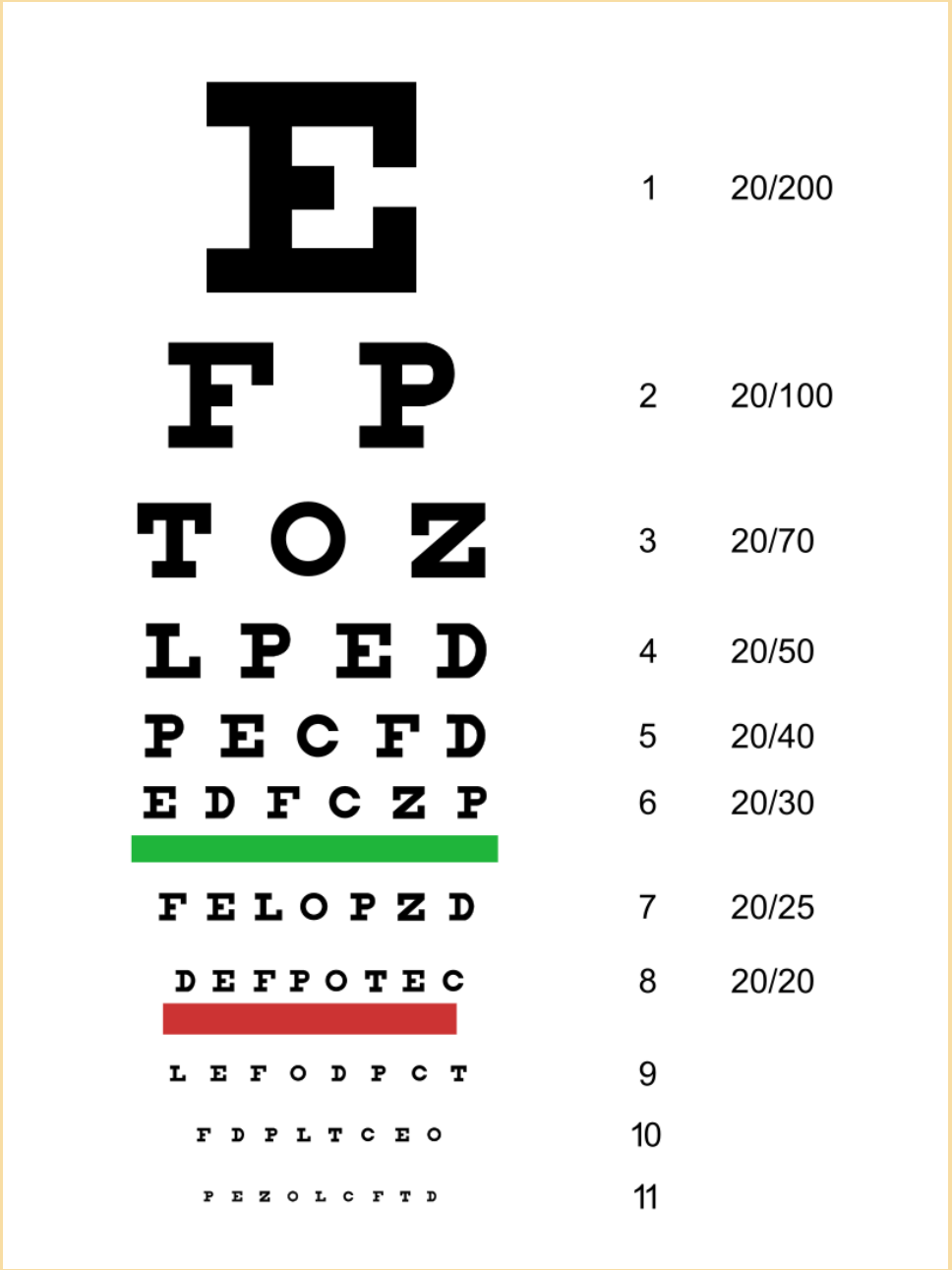
The scale will progress (usually) from large symbols (aka ‘optotypes’, sometimes pronounced ‘ototypes’) to smaller ones in a regularly spaced and sized fashion. Each of the optotypes should also consist of regularly spaced line elements, where the lines are as wide as the gaps between them. (I personally will often start my testing from smaller optotypes and work to the larger ones, this is frequently faster, less tiring, and it allows me to see how people naturally struggle with smaller characters and symbols.)



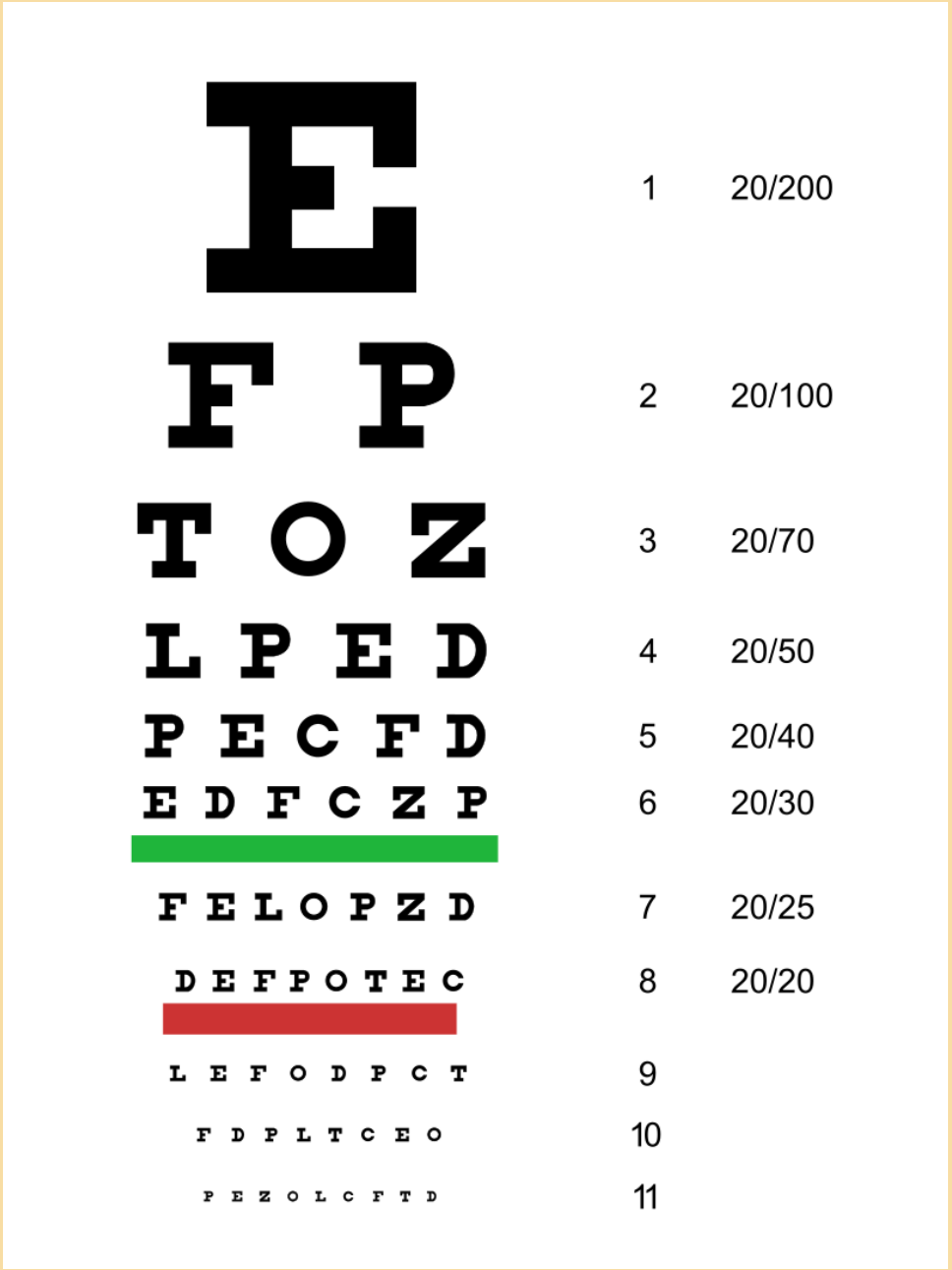
The top number in the ratio remains constant and indicates which scale is in use, that is, the reference distance – is the test calibrated for 20 feet/6 meters, or 10ft/3m, or closer, for example 40cm/16in.



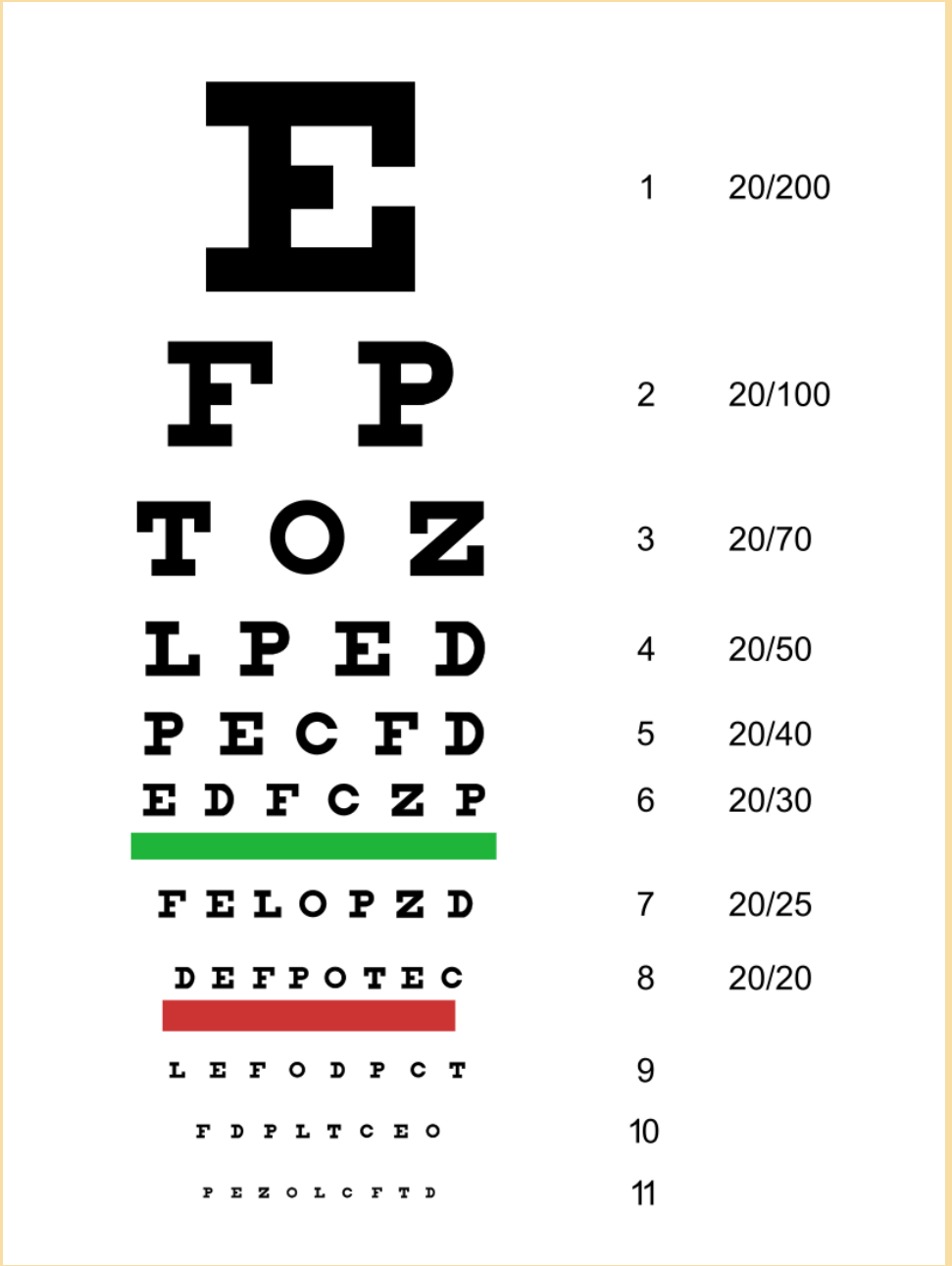
The bottom number indicates the limit of sight (visual spatial resolution) of the individual, and this number will vary from person to person, indeed, it will even vary from left to right eyes.



20/20 (6/6) would mean that the eye can see ‘at 20 feet what others can see at 20 feet’. Technically, it means they can resolve down to 1 minute of arc, at least.



20/40 would mean that the eye sees half as well as the 20/20 eye. Another way of putting this is that letters have to be twice as big as the 20/20 letters/optotypes to be seen, or the person would have to be twice as close to the letters/optotypes.



Other examples would be expressed as 20/15 (25% better than 20/20), 20/30 (50% worse than 20/20), 20/80 (significant visual impairment, or low vision, and 4x decline from 20/20, requiring letters 4x the size, or reducing viewing distance to ¼). Metric equivalents would be: 6/4.5, 6/9, 6/24. A quick review of these examples reveals them to be a simple ratio between optotype size and viewing distance.

Aside - 20/20 and the Limits of Human Sight

Eyeglass Prescriptions

Glasses Prescriptions

a) Sphere Examples

b) Astigmatism Examples

c) Auto-refractor Example

Advanced Topic: Spherical Equivalent (SE)

Prism, Add Power, and Other Details

Refractive ‘Error’ vs Refractive State

Summary