Living in the Material World

A Look at All the Choices Available to Patients and Eye-Care Professionals

(Optical Seminars Course # HS-12)

by

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Course Objectives

Upon completing this class, participants should:

- Have a more comprehensive understanding of today's most common lens material choices.
- Be able to more effectively guide patients toward lens choices that match lifestyle, safety needs, optics, and budget.
- Be aware of key features and benefits of major lens materials and communicate them clearly to patients.
- Know the practical meaning of **index of refraction**, **specific gravity**, and **Abbe value** as they apply to everyday dispensing.
- Have a better working knowledge of today's most common frame materials, including how they behave during adjustment and wear.
- Achieve a minimum score of 70% on the final assessment.

Lens Materials, part 1

"Living in the material world…
Can't say what I'm doing here
But I hope to see much clearer
After living in the material world"

It would be seven years before I entered the optical profession, when in 1973 my favorite Beatle, the late George Harrison, released his fourth solo album (notice I said album – not CD or MP3), *Living in the Material World*. It would eventually become #1 in the United States, with its most recognizable single being "Give Me Love (Give Me Peace on Earth)." To provide a bit of perspective, that album might have cost about $4. The average house cost $35,000; gas was 39-cents a gallon; the median income in the United States was about $10,500, and first-class postage stamps were only 8-cents. According to a long-time optician with the username Footprintz, posting answers on Yahoo Answers a few years ago, he claims that when he started in the profession in 1970, "an average pair of single-vision glasses cost $13-18, and bifocals were almost always under $25." He continued by describing what happened when he started to sell Christian Dior frames in 1973 or 1974. "[That] raised the prices dramatically to about $40 just for the frame…but everyone wanted them anyway. Then everybody with a label jumped into the act and designer frames took off." Of course, so did the prices.

I can't say for certain, but I'd bet the price of a first-class stamp today (which costs nearly 10 times what it did in 1973) has increased proportionally to the cost of a pair of prescription eyeglasses. Let's see. If we are to believe the information reported by VSP Vision Care as of December 2025, the national average price for a pair of single-vision prescription eyeglasses today is $337. That's about 23 times what it was in the early 1970s.

Of course, I have no way to verify it, but if I had to bet, the lenses in those glasses purchased in 1973 were made not of Trivex or polycarbonate, not high-index or even CR-39. Chances are, they were made of glass. I can remember when I began my optical career in 1980. I took a job at the JC Penney Optical Department in University Square Mall, in Tampa, Florida. Every memo, every sales meeting, every call from our District Manager seemed to focus on one thing: our effort to *sell* every patient on switching from glass to plastic lenses. How times have changed.

Today, an optical consumer has so many "choices" it might almost make his or her head spin trying to make an informed decision. Let's think about all the choices a typical presbyopic optical consumer might have to make when ordering a pair of eyeglasses:

While most Eye Care Professionals (ECPs) still prefer to discuss lens selection before discussing frame selection, let's say that a patient brings a frame that she has purchased online to your dispensary for you to put lenses in. You ask her how she decided which frame to purchase, and she tells you she spent weeks "shopping" online to find just the right style. It would not be an exaggeration to say then that this client has already had to choose from among tens of thousands of options. (Even in the average bricks-and-mortar dispensary there would probably be more than a thousand frames to choose from.) Regardless of how many frames she viewed and/or "tried on" online, your new patient finally whittled it down to that one perfect frame. If she thinks the most difficult decision is behind her, she's in for a rude awakening. While some of the following decisions are probably made concurrently, let's consider them one by one:

Lens Materials: The choice for lens material seems deceptively limited. After all, there are a limited number of lens materials from which to choose: Crown glass, standard index plastic (CR-39), mid-index plastic, high-index plastic, ultra high-index plastic, polycarbonate, Trivex, or Tribrid. That seems like a choice among only eight options. But not really. For example, if the patient wants glass, she will have to decide if she wants clear, tinted, Photography Extra, 1.53 crown glass, 1.6, 1.7, 1.8, or 1.9 glass! (As you probably know, if the client prefers the highest index glass lenses, she'll have to get them outside of the United States, as they have not been FDA-approved due to reduced impact resistance.) If the patient wants a plastic lens other than CR-39, there are several different lens manufacturers from which to choose, as well as the following indices of refraction: 1.53, 1.54, 1.55, 1.56, 1.60, 1.67, 1.70, 1.74, and 1.76. Those are just the ones with which I am familiar. There are probably even more. But wait! Most lens manufacturers don't offer many mid-index choices anymore. It's usually standard or high index. Of course, even after the patient decides on which lens material she wants, she may have to change her mind when it's discovered that the type of multifocal she needs is not available in the lens material she chose.

Multifocals: In our continuing example, the patient is presbyopic, does not want two separate pairs of glasses, so she must *choose* among...Round 22, Round, 24, FT-28, FT-35, FT-45, Executive, 7x28 Trifocals, 7x35 Trifocals, Executive Trifocals (good luck finding those), and of course a variety of occupational and specialty segments. These days, chances are your patient will not want any of those. She'll prefer a progressive lens. Last I checked, there were over 450 different progressive lenses listed in the Optical Lab Association's (OLA) *Progressive Lens Identifier*. (Once published yearly, the *Progressive Lens Identifier* is now only published online, and any ECP may access it for free. To do so, follow this link: https://epic.thevisioncouncil.org/). Assuming you and your patient make it past this part (meaning you have chosen a specific lens material and a specific progressive lens design), now you must help her navigate all the choices available when it comes to lens treatments.

Treatments: Without getting into the conundrum that certain lens materials already contain some of the available treatments (e.g., polycarbonate and Trivex have an ultraviolet filter inherent in the material), some of your patient's options include scratch-resistant coatings, ultraviolet filter, tint, photochromic, edge polish, mirror coating, anti-reflective coatings, and more. Within each of those choices, there are many sub-choices as well. You want Transitions lenses? Inside this one category of photochromics, Transitions itself has moved forward. Transitions GEN S launched as the newest generation and has been rolling it out globally in 2025; it is also positioned as the replacement for Signature GEN 8 during the rollout. You and your patient have chosen a specific Varilux design in polycarbonate lenses with an AR coating? Oh wait…when it comes to that AR coating will you prefer Easy, Avance, Rock, or Prevencia. (By the way, it is an extraordinary optician who would be able to explain the differences clearly and concisely among all those choices to an uninformed patient. What makes an Avance better than an Easy? What's the difference between Rock and Avance, etc.?)

Miscellaneous: This category would include everything else, including second-pair options (choices), and anything that is unique to your individual practice. For example, I know a local dispensary that includes a 90-day "manufacturers defect" warranty with all spectacle purchases but also offers both a one-year and two-year warranty option on all frames.

"Met them all here in the material world
John and Paul here in the material world
Though we started out quite poor
We got Richie on the tour…"

Sorry, but the song is stuck in my head as I write this and while Harrison's lyrics meant something else altogether, it applies here. While our patient's spectacles might have cost $50-60 in 1973, depending on the choices she makes today, she may spend $500, $1,000, or even more. Let's look more closely at Lens Materials and Frame Materials.

Lens Materials, part 2:

While there are certain other characteristics to consider (e.g., availability in preferred multifocal, UV absorption, impact resistance, minimum thickness requirements, and more) we will review each material's 1) Index of Refraction, 2) Abbe Value, and 3) Specific Gravity. Respectively, these characteristics will determine 1) Lens thickness; 2) Dispersion and color fringing; and 3) Weight. We will also concentrate on each material and its uses, indications, and contraindications.

Glass: As the very word suggests, for a long time, glass lenses were standard when you bought a pair of prescription eyeglasses. Think about it, we don't call them eyeplastics! We still call them eyeglasses. There are some ECPs who absolutely refuse to use glass lenses when making eyeglasses. It's a good thing they're practicing today, because if they were practicing in the 1970s or any time before, glass would have been the only practical choice. While today ECPs try to move patients from plastic lenses to polycarbonate or Trivex, it really was a hard sell when I began in 1980. Trying to move a patient from glass to plastic was a real challenge. After all, some of the advantages of glass lenses could not be denied, and to a degree these advantages still exist today. Glass lenses have a high degree of scratch resistance, without having to add any extra coatings to increase scratch resistance. Though the optical properties of standard CR-39 are very close, there is also no question that glass lenses offer outstanding optical clarity. And until recently, it was also the most affordable lens material.

One of the earliest owners of the Carl Zeiss organization, Ernst Abbe (1840-1905) laid the foundation for modern optics. He is credited with many optical inventions, and professional opticians mostly remember him for the eponymous Abbe Number. The Abbe Number is the measure of a lens's dispersion in relation to the refractive index of a material. The higher a material's Abbe Number the less dispersion or color aberration will occur. Regarding this one measure, the higher the Abbe Number, the better. Here is a table of some of today's most used lens materials, and a few not-so-commonly used lens materials:

LENS MATERIAL	INDEX OF REFRACTION	SPECIFIC GRAVITY	ABBE VALUE
Crown Glass	1.525	2.54	59
Photo-Gray Extra Glass	1.523	2.41	57
High-Index Glass (*)	1.60	2.62	42
High-Index Glass (*)	1.70	2.93	35
High-Index Glass (*)	1.80	3.37	25
High-Index Glass (*)	1.90	4.02	31
Plastic CR-39	1.49	1.31	58
Mid-Index Plastic	1.54	1.21	47
Mid-Index Plastic	1.56	1.22	36
Tribrid	1.60	1.23	41
High-Index Plastic	1.60	1.23	36
High-Index Plastic	1.66	1.35	32-33 (*)
Ultra-High Index Plastic	1.74	1.47	32
Polycarbonate	1.58	1.20	30

Trivex	1.53	1.11	43
BluTech	1.56	1.23	46

* (*values vary by manufacturer and formulation*)

Due to its Abbe Number (highest in the table), there is no question that glass still provides the crispest vision possible, however, glass lenses have become very unpopular over the past couple of decades due to their weight (notice that the Specific Gravity numbers are highest for all the glass lenses in the table), and the danger that it could shatter upon impact, despite the fact they are tempered to raise their impact resistance. Remember, the highest indices of glass lenses are not available in the United States. Other disadvantages of glass, ophthalmic lenses include limited availability in different lens designs, and higher cost-of-goods.

PhotoGray Extra: At one time, PhotoGray Extra (PGX) lenses by Corning were considered the industry gold standard when it came to photochromic lenses. These days, Transitions has all but wiped PGX off the face of the optical landscape. If a patient requests or requires glass, this photochromic option could be considered. They are still available in limited parameters (check with your lab). PGX's Abbe Number, Index of Refraction, and Specific Gravity is so close to those of clear glass, they shouldn't present any issues.

High-Index Glass: As you can see, this category includes glass that has indices of refraction of 1,6, 1.7, 1.8, and 1.9.

As most ECPs know, the ability of eyeglass lenses to bend light is determined by the Index of Refraction of the lens material. Refractive Index is the ratio of the speed of light traveling through air to the speed of light when it passes through a particular lens material.

The speed of light decreases the more it is refracted as it passes through a lens material. That's why lenses that bend light more efficiently have a higher Index of Refraction than those that bend light less efficiently. That is also why lenses with a higher refractive index are thinner than lenses of the same power made of materials that have a lower refractive index.

Bottom line: The higher the Index of Refraction, the thinner the lens will be. Industry lens expert Tony Albarella explains: "As one travels up the index scale, anything over 1.74 switches from high index plastic to high index glass. Glass lenses have some innate weaknesses – they're more brittle, for example, and weigh more than plastic – but also enjoy some innate strengths; they're highly scratch resistant, for example, so require no additional anti-scratch coating. Glass lenses also provide a visual clarity that plastic lenses cannot match.

While high index glass lenses are heavier than high index plastic lenses, one should not conflate them with standard (low index or mid-range index) glass. Because high index lenses require less physical material to create a prescription, they are much thinner than standard glass lenses, shaving off valuable ounces. A prescription fashioned of high index glass will be significantly lighter than the same prescription in standard glass. That weight reduction, for anyone requiring severely high prescriptions, means a lot in terms of fit and day-to-day comfort.

Along with weight reduction, 1.9 lenses are also notable for being the thinnest possible. Again, if your prescription is very strong, standard glass or plastic material will result in very thick lenses with a deep curvature. This limits the frame styles you can select. Rimless, semi-rimless, and indeed just about any wire frame choice would be out; you'd require thick-framed glasses to help mask the ends of the lenses, which protrude from the inner side of the frames toward the face. 1.9 lenses are nearly 80% thinner than standard, 1.5 low-index lenses." Remember, these lenses are very brittle, heavy, and will crack or break if dropped. It is a poor choice for most people.

For handy reference, here's a checklist of the advantages and disadvantages of 1.9 high index glass lenses:

- Highest index available
- Available in glass form only
- Are approximately 80% thinner than standard 1.5 index lenses
- Highly effective for strong "minus" prescription
- Great for nearsightedness (also known as shortsightedness)
- Available only in single vision (no bifocal, trifocal, or progressive trifocal options can be ordered)
- Innately high level of scratch resistance
- Hard surface also makes it brittle
- Great replacements for extremely thick lenses
- More expensive than other low, mid-range, or high index options
- Anti-reflective coating is strongly recommended

Plastic, CR-39: Columbia Resin #39 was the 39th formulation created by the Columbia Resins Project in 1940. While first designed for the fuel tanks of Air Force bombers, it is now the most widely used material for spectacle lenses. It is a trademarked product of PPG Industries. It was first used for eyeglass lenses in 1947. Of course, the biggest selling point for switching patients from glass to plastic was that generally, plastic is half the weight of glass. While they are not as pristine as glass, CR-39 lenses will produce better optics than polycarbonate or Trivex. Additionally, they will be 30-40% thicker. While they are infinitely safer than glass, CR-39 lenses can still shatter upon impact, which is why most ECPs use polycarbonate or Trivex for children, patients with only one functional eye, and people involved in hazardous activities.

Mid-Index and High-Index Plastic: With most prescriptions there is little to no advantage in choosing a mid-index or high-index lens. The cost would be higher and the advantages regarding thickness and weight would be negligible at best. Additionally, consider the Abbe of CR-39 (58) vs. the Abbe of 1.74 (33). The difference would be problematic, requiring an AR coating. That is why manufacturers do not even sell 1.74 lenses unless they have been treated with an AR coating.

1.67-1.70 high-index plastic is considered the most basic high-index these days, as more manufacturers are discontinuing the mid-index (1.5-1.6) lenses. It is the most popular choice. If your patient is concerned about the cost of his or her glasses, this would be a good choice. 1.7 has low distortion and is thinner and more lightweight than 1.6 lenses. 1.74 would only be slightly thinner and should probably only be considered with very high (+/- 9.00 D) prescriptions.

High-index lenses are denser than standard, CR-39 lenses. This is what makes them thinner and lighter than the standard lenses. Of course, the high density also increases the amount of light that each surface reflects, making it almost required to place an anti-reflective coating on them. The higher the index the thinner the lens will be, but the optics will be worse. Additionally, though not true for all manufacturers, generally the higher the index the fewer choices there will be in multifocals.

Even though high-index lenses are generally more scratch resistant than standard lenses, high-index lenses are less impact resistant than standard lenses. If safety is a primary concern, high-index lenses are a poor choice indeed.

Most high-index lenses are available in clear, single vision, and a few progressive designs. Even fewer are available in polarized or Transitions, so check availability with your lab. The website allaboutvision.com is a good resource for further information on high-index lenses. You could also direct your patients to the high-index page for educational purposes. Check out their article at: www.allaboutvision.com/lenses/highindx.htm.

Polycarbonate: Originally developed in the 1970s for aeronautical applications (it is still used for astronaut visors and space module windshields), polycarbonate has been the lens-of-choice when it comes to maximum impact-resistant eyeglasses for nearly three decades. I first began to dispense them in the mid-1980s. Since then and to present day, polycarbonate is considered standard of care for children's glasses, sports goggles, and for anyone who requires maximum impact resistance. Until recently, they were also the best choice for safety regarding three-piece, drill mountings. All About Vision also publishes a great article explaining the relationship between polycarbonate and children.

Most other plastic lenses are made from a cast-molding process, where a liquid plastic material is baked for long periods of time in lens forms, solidifying the liquid plastic to create the finished product. On the other hand, polycarbonate is a thermoplastic that starts as a solid material - small pellets. Through an injection-molding process, the pellets are heated until they melt. The liquid polycarbonate is then rapidly injected into lens molds, compressed under extremely high pressure, and cooled to form a finished lens product – all in a matter of minutes.

Polycarbonate is lighter (20-25%), thinner (about 30% or more, depending on center thickness), and more than 10 times more impact resistant than ordinary CR-39. Due to its increased safety, some labs will surface lenses with as low as 1.0 center thickness, thus creating a much thinner finished lens. Another advantage to polycarbonate lenses is that a UV inhibitor is added to the polymer, so that without adding any other coatings, poly effectively blocks 100% harmful UV rays. "Raw" polycarbonate is prone to scratching, and nearly impossible to tint, so manufacturers automatically add a highly scratch-resistant coating to both sides of the finished lens. Again, a great place for consumers and inexperienced ECPs to learn more about polycarbonate and other options is at allaboutvision.com. Here's a direct link: www.allaboutvision.com/lenses/polycarb.htm.

Due to its low Abbe Number, in high prescriptions, patients may have difficulty with dispersion issues especially toward the periphery of the lens, and even more so in larger-sized frames. Since polycarbonate's Index of Refraction is higher than plastic or glass, AR is highly recommended. Whereas an uncoated CR-39 lens is losing nearly 8% of light to reflections, an uncoated polycarbonate lens may approach 12% of lost light due to reflections. With polycarbonate lenses, the larger the frame and the stronger the prescription, the more likely the patient is to experience challenges with the vision in the periphery of the lens. Take a moment to review the table below. Remember, more light transmission ensures better vision. Consider the following table of typical light transmission:

Material	Index	No AR	With AR
CR-39	1.50	92.06 %	99.10 %
Glass	1.52	91.40 %	99.23 %
Trivex	1.53	90.23 %	99.53 %
Polycarbonate	1.58	89.41 %	99.00 %
High Index	1.60	89.02 %	98.88 %
High Index	1.67	87.06 %	98.23 %

Trivex: In 2002, PPG introduced the optical community to Trivex, calling it, "a revolutionary new category of lens material to eyeglass wearers around the world." When you consider that 80 to 85% of your patients' prescriptions fall between -3.00 and +3.00, Trivex might be just that!

In short, Trivex possesses the same impact-resistant properties as polycarbonate, and even surpasses poly's impact resistance when it comes to pointed projectiles. This is due to its superior tensile strength. Benefits to your patients include a higher Abbe Number for greater optical clarity, and its specific gravity (1.11) makes it currently *the* lightest ophthalmic lens material available. Another benefit to patients wearing three-piece drill mounts (other than weight and impact resistance), is that Trivex is not sensitive to harsh solvents such as acetone. Every experienced ECP knows that if even a drop of acetone makes its way into a drilled hole, it will immediately crack and craze the lens. Not so with Trivex. One word of warning though: Even though it is the lightest lens material, Trivex is not the thinnest. Its Index of Refraction is not much higher than standard CR-39, so don't expect much in the way of thinness. On the other hand, given that small frames still rule in terms of fashion, and that Trivex may also be surfaced to a 1.0 mm thickness, unless your patient's Rx is severe, thickness should not be an issue. For more details and technical specifications for Trivex visit: www.ppgtrivex.com. Remember:

Modern labs and drilling techniques have improved, but solvent sensitivity still matters, and Trivex remains the best choice when you want toughness plus better optics than poly, along with maximum resistance to solvents (like acetone) with drilled lenses.

Tribrid: According to a press release issued by PPG when it was first released, "Tribrid lenses were developed by PPG's optical products business using a hybrid approach merging elements of the chemistry for Trivex lens material with traditional high-index lens chemistry. The result is a high-index lens that provides the patient with a superior combination of performance benefits, according to Christine Camsuzou, PPG general manager, optical materials. Suited to patients with higher prescriptions within the +/-3.00 to +/-7.00 diopters range, Tribrid material features optical clarity (Abbe number 41), lightweight comfort (density 1.23 grams per cubic centimeter), thinness (refractive index 1.60), impact resistance (withstands more than 160 times the energy of the U.S. Food and Drug Administration drop ball test) and protection (100 percent protection from ultraviolet radiation)."

"'Tribrid material represents the next evolution in lens material technology,' Camsuzou said. 'It expands upon the foundation of *Trivex* material that North American opticians have come to trust – clarity, lightweight, strength, and UV protection – and makes similar attributes available in a high-index lens to meet the everyday visual needs of patients with higher-prescription requirements.'" For more information about Tribrid lenses, and current availability, go to: www.shamir.com and search for "Tribrid."

BluTech. BluTech is a lens material developed by VSP and Signet-Armorlite to block out virtually 100% of all HEV blue light and ultraviolet rays using ocular lens pigment infused with melanin. According to VSP's literature: "This infusion of pigment provides the same protection, contrast enhancement, and color perception to the eye as the natural yellow-brown coloration of the human crystalline lens." In addition to blocking UV and HEV, BluTech boasts high impact resistance, natural depth and color perception, and a slight reduction in glare. For more information on BluTech lenses go to the VSP website.

Finally, one mistake I think inexperienced ECPs can sometimes make is to learn of the benefits of some new lens material (e.g., Trivex is the lightest), and begin to use it for every single patient, every single time. Conversely, sometimes they learn of a negative characteristic of a material (e.g., polycarbonate can cause a drilled hole to crack) and stop using it altogether. Neither of those approaches seems right-minded. Today's successful dispenser is the one who always keeps the health and welfare of his or her patients foremost in the lens decision making, learns all that can be learned about all existing options, and offers recommendations on a case-by-case basis. This is what I like to call a blended approach to dispensing ophthalmic lenses.

Frame Materials

"As I'm fated for the material world
Get frustrated in the material world…"

Given all the choices in lens materials, who wouldn't get frustrated? When it comes to frame materials, it's a bit more finite. It's been a long time since I've seen one of our journals delve into the topic of frame materials, which can sometimes seem a bit esoteric. On the other hand, information is power. Furthermore, the ability and the willingness to share information is power times ten. Therefore, the more information an Eye Care Professional can amass, the more information she can share. And if nothing else, the next time a patient asks, "What's the difference between beryllium and Monel?" or "Is beta titanium the same thing as titanium?" rather than responding with an uncomfortable pause and then an unprofessional "Umm...," the response can be a confident and professional, thoughtful exchange of information.0000000

The best way to start is to separate frame materials into two distinct categories: metal and plastic. While plastic is surging in sales, my anecdotal experience affirms that in the battle for frame material domination, metal is still king. Although they are generally thinner and lighter, metal frames are perceived as, and in fact, are usually more durable. Since metal frames are generally easier to adjust, and are not as affected by heat, they are more likely to maintain their original adjustment. Metal frames are more difficult to break than plastic frames and are more easily bent back into shape when necessary. Metal frames won't discolor when exposed to UV, at least not as readily as most plastic frames. Additionally, metal frames generally are lighter weight overall, because less frame material is necessary than with a plastic frame. Ironically, on the other hand, some patients will complain that the thinner temples are *less* comfortable behind their ears. Let's take a little closer look at some of the specific differences between the two categories.

Metal. One of the most misunderstood metals is **Monel**. It is usually capitalized because it is a trademark of the Special Metals Corporation, which mixes up to two-thirds nickel with other alloys like copper, tin, and iron to form it. Monel is extremely corrosive resistant, which is why it's not only used in eyeglass frames, but also kitchen sinks. However, it is not corrosion proof; for some people, Monel can react negatively with their skin chemistry. But this is preventable if the right kind of plating, such as palladium or other nickel-free metals, is used.

Beryllium is a relatively rare element found in the Earth's crust, nevertheless it is sometimes used in metal eyeglass frames. It can increase hardness when mixed with other metals, which is why its presence in nickel-rich frames is a plus. In its natural state it is lightweight and steel gray. Because it is so resistant to corrosion, it's a good choice for people with high skin acidity, or who spend a lot of time around water - especially salt water. Some people worry that beryllium has toxic properties, so don't be surprised if some patients react strangely if they learn their frame contains it.

Aluminum is the most abundant metal naturally found in the Earth's crust. In fact, it is the third most abundant element after oxygen and silicon. Frames made of aluminum are lightweight and corrosion resistant. Years ago, aluminum was a popular material choice, and these days it is making a comeback especially among higher-end frame styles, as it creates a very distinctive and elegant look.

I like to refer to **Stainless Steel** frames as the poor man's titanium. Stainless steel frames are lightweight, have a low toxicity and are strong. Stainless steel frames are usually nickel-free and thus hypoallergenic. Stainless steel is readily available and usually much less expensive than titanium. It is an alloy of steel and chromium, which provides excellent resistance to corrosion, abrasion and heat. On the other hand, it also is not corrosion proof. Under low oxygen and high salinity environments, it can degrade. (This is rarely an issue in everyday wear, but can matter for patients who live in coastal environments or spend significant time around saltwater.)

Titanium is probably the most (if not the only) patient-requested frame material - hands down. It is a low density, high strength metal that was discovered in the late 18th century, and named for the Titans of Greek mythology. It has the highest strength-to-weight ratio of any metal. It is as strong as most steels, despite it being nearly 50% lighter than most others. It is strong, hypo-allergenic, and flexible. Despite it being a silvery color in its natural state, with a little plating added, it is available in a wide array of colors. A real confusing issue for some ECPs is understanding the difference between titanium and **Beta Titanium**. Titanium alloys are generally categorized as either alpha alloys, beta alloys, or in some cases alpha/beta alloys. Alpha alloys are usually stronger and less likely to break. Titanium is categorized as alpha based on the temperature used to process it and the different alloys used in the process including aluminum and tin. Beta titanium is usually a more flexible finished product, which makes it perfect for an economical three-piece, drill-mount chassis. Also categorized based on the temperature at which it is processed, some of the alloys used include exotic-sounding molybdenum and vanadium, and the more familiar: copper and chromium. **Flexon** is a memory-metal titanium originally developed by Marchon. It is very strong and very flexible, always returning to its original shape when bent.

Plastic. For patients looking to make a bold, vibrant, colorful statement, **Cellulose** Acetate, aka **Zyl**, is the frame material of choice. Zyl, which is short for zylonite is popular because it can assume such a wide array of color combinations, patterns, and textures. It is the most common plastic frame material. Frame fronts and temples can be cut from blocks of zyl extruded from sheets of cellulose acetate, or the zyl can be liquefied and then injection molded. The former method yields a stronger and more stable finished product, while the latter are less expensive and do not hold their shape very well, especially at higher temperatures. In both cut block and injection-molded zyl frames, metal cores are usually added inside the core of the temples for greater stability and adjustability. If zyl frames are exposed to temperatures exceeding 150-degrees Fahrenheit plasticizers within the zyl begin to rise to the surface, turning the zyl an opaque, milky white color. Additionally, perspiration, overexposure to ultraviolet, and even body oils and some make-up can cause zyl to degrade. When combined with polycarbonate or Trivex™ lens materials, a finished pair of zyl eyeglasses can be lightweight and comfortable.

A more recent innovation is adding laminate finishes to zyl frames which further expands available designs. Unrelated fun fact: Cellulose acetate is also used in the manufacturing of cigarette filters and high-quality playing cards.

Alcohol Sensitivity Warning (Injected Plastics)

Some modern frames, particularly lower-cost fashion frames, including certain Safilo Levi's models are manufactured using injection-molded plastics such as **cellulose propionate** or proprietary nylon-based blends rather than block-cut cellulose acetate (zyl). These materials are lightweight, flexible, and inexpensive to produce, but they rely on plasticizers to maintain flexibility and structural integrity. Exposure to alcohol (including isopropyl alcohol commonly used for disinfection) can rapidly extract or destabilize these plasticizers, causing the frame material to soften, craze, warp, crack, or in extreme cases, appear to "disintegrate" in the hands of the optician. Unlike traditional zyl frames, which may turn cloudy or brittle over time, these injected plastics can fail almost instantly when exposed to alcohol or other aggressive solvents. For this reason, alcohol-based cleaners should never be used on frames unless the manufacturer specifically states compatibility, and opticians should rely instead on mild soap and water or manufacturer-approved cleaning solutions. This serves as an important reminder that not all "plastic" frames behave the same, and material awareness is essential to avoid accidental damage during routine handling, cleaning, or adjustments.

Nylon frames are a good choice for sports and safety. Introduced more than 75 years ago, the original nylon frames proved to be too brittle. To fix this problem manufacturers began to switch to compounded or blended nylons using polyamides to decrease brittleness and increase flexibility. One drawback to nylon is it can only be made in solid, opaque colors, thus limiting it in terms of fashion.

There are several other plastic frame materials available in varying quantities and styles. These include **CFG** or **Carbon Fiber Graphite**, which is lightweight and durable. **Optyl**, which is made from an epoxy resin, is high in luster, and very hypo allergenic. It also has "memory" in that if highly heated it will return to its original shape. To adjust an Optyl frame it must be greatly heated and held in place while it cools for it to hold the adjustment. **Cellulose Propionate** is produced by an injection molding process and can be made thinner than frames made of cellulose acetate. While it also has infinite color options, the coloring more readily fades than frames made of zyl - especially block zyl. Too much heat can shrink this frame material. A common mistake made by uninformed or inexperienced ECPs is heating this type of frame to insert the lenses. Manufacturers recommend these lenses be mounted using a cold-mounting technique. Cellulose propionate is hypo-allergenic to a degree, lightweight and durable.

While time and space does not allow us to cover *all* frame materials (after all we didn't even mention **gold**, **wood**, **buffalo horn**, or even **velvet-wrapped**!) Another company, Pair, has taken the idea of magnetic clip-ons to a new level. Rather than just offering magnetic sunglass clips, they offer dozens of different designs and colors to be placed over a "base" frame. Based on anecdotal patient requests they seem to be growing in popularity. Check out their innovative designs at: www.paireyewear.com.

Hopefully now it will be easier for front-line ECPs to have a well-informed, constructive conversation when it comes to the most common materials in their eyeglass frame and lens arsenals.

Good luck on the Final Assessment.

Final Assessment

1. Choosing the lens material best suited to each individual patient was described in this module as:

    a. A blended approach
    b. A customized approach
    c. A professional approach
    d. An individualized approach

2. Which lens material starts off as solid pellets which then are melted and molded?

    a. Trivex
    b. Tribrid
    c. Polycarbonate
    d. Transitions

3. Which lens material had its beginnings in the aeronautical field?

    a. Polycarbonate
    b. Trivex
    c. Tribrid
    d. Ultra-high index plastic

4. 1.9 high-index glass is:

    a. The lightest weight glass lens available
    b. The safest glass lens available
    c. Available in a wide variety of progressive lenses
    d. Not readily available in the United States

5. According to VSP, the average cost of a pair of single-vision eyeglasses in the United States in 2025 is:

    a. $ 137
    b. $ 337
    c. $ 437
    d. $ 537

6. Ernst Abbe did most of his developmental work for the ophthalmic industry while working for which company?

   a. Essilor
   b. Carl Zeiss
   c. Hoya
   d. VSP

7. The lens measure that mostly determines thickness is:

   a. Index of refraction
   b. Specific gravity
   c. Abbe number
   d. Dispersion quotient

8. Plasticizers within zyl can emerge, causing it to turn an opaque, milky white color. This is caused by among other things:

   a. Temperatures around 65-degrees Fahrenheit
   b. Perspiration and body oils
   c. Over exposure to Gamma rays
   d. Cheap materials

9. Stainless steel is not a corrosion-proof metal, especially for:

   a. Use at high altitudes
   b. Use in high UV environments
   c. High-salinity environments
   d. Glass lenses

10. Because of its resistance to corrosion, especially around salt water, which frame material should be considered?

   a. Beryllium
   b. Aluminum
   c. Monel
   d. Nickel

11. Due to its superior impact resistance, which lens material could be surfaced to a center thickness as little as 1 mm?

a. Polycarbonate
b. Photogrey-X glass
c. CR-39
d. 1.74 High-index

12. The ability of a lens to bend light is determined by its:

a. Abbe number
b. Index of refraction
c. Specific gravity
d. Center thickness

13. 1.9 high-index glass lenses would be approximately how much thinner than standard, 1.5 index lenses?

a. 40 %
b. 50 %
c. 60 %
d. 80 %

14. Which of the following statements is true?

a. With Abbe number, the higher the clearer
b. With specific gravity, the lower the heavier
c. With index of refraction, the higher the thicker
d. With index of refraction, the higher the clearer

15. All things being equal, which lens material would yield the lightest-weight glasses?

a. CR-39 with a 2.0 center thickness
b. Polycarbonate with a 1.0 center thickness
c. Trivex with a 1.0 center thickness
d. Tribrid with a 1.2 center thickness

16. High-index lenses are generally:

a. Thinner than CR-39 lenses
b. Lighter than Trivex lenses
c. Safer than polycarbonate lenses
d. More expensive than Transitions lenses

17. CR-39 lenses:

a. Are the most popular lens material
b. Are the safest lens material
c. Are the lightest lens material
d. Are the heaviest lens material

18. According to PPG, what percentage of Rxs in the United States fall between +/- 3 diopters?

a. 20-25%
b. 40-45%
c. 60-65%
d. 80-85%

19. Tribrid was first introduced by PPG in what year?

a. 1993
b. 1999
c. 2003
d. 2013

20. The best approach to choosing a lens material is for the ECP to:

a. Find one material and stick to it
b. Do a lifestyle interview and choose the best material for each patient
c. Always use polycarbonate or Trivex
d. Never use glass lenses

21. If your primary concern with a pair of three-piece, drill-mounted eyeglasses is to protect the drill holes from cracking, while maintaining maximum impact resistance, what would be your lens of choice?

a. Crown glass
b. CR-39
c. Polycarbonate
d. Trivex

22. Trivex was first introduced by PPG in what year?

a. 1982
b. 1992
c. 2002
d. 2012

23. CR-39 is about how much thicker than polycarbonate?

a. 10-20%
b. 30-40%
c. 50-60%
d. 70-80%

24. If your patient wishes to make a bold statement involving a myriad of bright colors of varying hues, which frame material would work best?

a. Zyl
b. Monel
c. Titanium
d. Flexon

25. Having the highest strength-to-weight ratio, how much lighter is titanium than most other metals?

a. 30 %
b. 40 %
c. 50 %
d. 60 %

26. The front surface of an uncoated (no AR) CR-39 lens reflects how much light? A little more than:

a. 4%
b. 8%
c. 12%
d. 16%

27. 1.49 is the index of refraction of which lens material?

a. CR-39
b. Polycarbonate
c. Trivex
d. PGX glass

28. All things being equal, which lens material would yield the heaviest pair of eyeglasses?

a. Crown glass
b. PGX glass
c. Trivex
d. 1.9 high-index glass

29. Which is the most flexible metal listed below?

a. Alpha titanium
b. Beta titanium
c. Monel
d. Aluminum

30. Which frame material is made from the most abundant metal found naturally in the Earth's crust?

a. Aluminum
b. Beryllium
c. Titanium
d. Nickel

31. Which frame material is usually about two-thirds nickel mixed with other alloys such as copper, iron, and tin?

a. Monel
b. Stainless steel
c. Nickel-plated
d. Titanium

32. According to PPG, what is the ideal range of prescriptions for its Tribrid material?

a. +/- 1.00 D to +/- 5.00 D
b. +/- 3.00 D to +/- 7.00 D
c. +/- 5.00 D to +/- 9.00 D
d. +/- 1.00 D to +/- 9.00 D

33. Even after being treated with a high-quality AR coating, which lens material listed below will still reflect the most light?

a. CR-39
b. Polycarbonate
c. Trivex
d. 1.67 high-index plastic

34. CR-39 was first used for ophthalmic lenses in what year?

a. 1937
b. 1947
c. 1957
d. 1967

35. With most prescriptions today:

a. There is little or no advantage in choosing mid or high-index plastic
b. Polarized lenses are not available
c. The prescriptions are presbyopic
d. Glass would not be available

36. In the strictest terms of optical clarity, which lens material listed below would yield the best results?

a. Crown glass
b. CR-39
c. Trivex
d. Tribrid

37. The lens measure that mostly determines dispersion is:

a. Index of refraction
b. Specific gravity
c. Abbe number
d. Dispersion quotient

38. The lens measure that mostly determines weight is:

a. Index of refraction
b. Specific gravity
c. Abbe number
d. Dispersion quotient

39. Which is generally the most affordable lens choice?

a. Glass
b. Polycarbonate
c. CR-39
d. Transitions

40. In the latest online edition of the *Progressive Lens Identifier*, designs of about how many different progressive lenses are featured. Just over:

a. 150
b. 250
c. 350
d. 450