Demystify: *demystify* /dəˈmɪstɪfaɪ/ (used with object), to make (something) clear and easy to understand: to explain (something) so that it no longer confuses

-- Merriam-Webster Dictionary
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1. INTRODUCTION

For many years the waxroom was the mysterious domain of the super-techs. Behind closed doors, they worked like modern-day alchemists to change their secret wax concoctions into gold medals and sponsorship contracts for their athletes. The most successful of these wax techs at the World Cup and Olympic levels gained legendary status, but they are not alchemists. Their skill comes from a combination of knowledge and many years' experience of testing, trial and error. With this they put the science of waxing to work for them. While there is no absolute substitute for those years of experience, the average person can approach the super-techs’ results through an understanding of the scientific principles of wax performance.

We simplified these principles into everyday language to offer a thorough understanding of how wax works, not only to skiers and snowboarders and parents and coaches without technical backgrounds, but also to those super-techs, so they can learn the reasons behind their observations.

Understanding why a certain wax works (or not) will give you a competitive edge, move you many steps up the knowledge ladder, and give you something close to the equivalent of a lot of experience, without all that trial and error.
2. A BRIEF HISTORY OF SKI WAX

Ski wax is a lubricant that reduces friction between the base and the snow. We suspect that the need for this friction reduction was realized as soon as people started using snow sliders for transport. There are some very early references to skis, but the most unequivocal is a painting dating from the 1200's that shows Scandinavian hunters or warriors on skis. There is no information on waxing during those early days, but we know that charioteers used animal fats as axle grease/sealant at 1300 B.C., so I would be surprised if the innovative Scandinavians had not made that leap.

First known use of a lubricant, 1300 B.C.       Warriors (hunters?) on skis, 1200 A.D.

The first references to ski waxes were recorded in the mid-1800's and two concoctions were prominent: Black Dope and Sierra Lightening, secret sauces used by California gold miners. These guys were racing downhill on wooden planks up to 14 feet long, using a single pole as a brake. Most likely the screaming heard during those races was partly from the exhilaration of tearing downhill and partly from the pain of broken bones. The two waxes were fairly similar in composition and, if you are tempted to reproduce the formula, this is what you'll need to cook it up: One pound Spermaceti wax, two ounces pine pitch, one ounce camphor, three ounces balsam fir tar oil and three ounces spruce oil. Spermaceti wax used to be derived from Sperm whale blubber and in these formulas it provided waterproofing and some lubrication. You can't buy Spermaceti derived from whales anymore; today's product is a synthetic analog. The remaining items were natural resins and tars (pine pitch, balsam fir tar oil) and thinning solvents of the turpentine type (spruce oil, camphor) and their function was to seal the wooden ski and prevent icing.

California miners used secret wax formulas on wooden skis, 1852 A.D.
As technology evolved and aluminum skis and skis with cellulosic plastic bases became available, the need for the sealant part of the formula disappeared and the transition was made to straight lubricants. Petroleum-derived waxes and petrolatum (Vaseline) were the main components. In the mid-1950's polyethylene bases were discovered and the shift to petroleum-derived waxes was complete.

Ski wax technology grew along with ski technology and several wax companies were established in the first half of the 20th Century. Early waxes were made mostly from hydrocarbons, also called paraffins, which are natural products derived from crude oil. The wax companies discovered that softer waxes work best on soft snow and harder waxes are more suited to hard snow. Dyes were added to differentiate the hardness of the waxes, and the color-coding still used today began. These natural waxes improved glide on many types of snow but even the hardest ones were too soft for very cold snow. Synthetic hydrocarbon waxes, derived from coal, proved to be very efficient hardeners and were later incorporated in formulas for very cold snow. Hydrocarbons, both natural and synthetic, are available from companies like Mobil and Sasol, and are commodity products costing a few dollars per pound in ton quantities.

This 1950's wax could be rubbed on or ironed in. The legendary name on the label did not hurt sales

U.S. wax in warm and cold formulas, from the now defunct Leisure Products, a Colorado Company

The made-in-the-USA Fall Line waxes were very popular in racing

There is no question that the early products were very limited and did not begin to cover the variety of snow conditions that the competitors encountered at that time. This opened the door to a whole culture of wax alchemists who secretly mixed a little bit of this and that with the waxes to create their own special (and secret) formulas. Fabric brightener, newspaper ink, and metal shavings are just a few of the secret ingredients we know were used. The technology exists today to cover every conceivable snow situation; the products’ functions are laid out clearly, and anybody with the funds has access to the same waxes that were once available only to the likes of Bode Miller and Hermann Maier.
3. FRICTION AND LUBRICATION

With science, it’s always good to start at the beginning, so let’s take a look at the basics:

Friction: The resistance that one surface or object encounters when moving over another.
Lubrication: The reduction of friction by the application of a substance called lubricant.

Understanding Snow Friction

The figure on the left shows the forces at work as a skier is preparing to move down the hill. The first drawing shows the skier on flat ground. The only force is his weight (W) and there is no forward motion. As the slope increases (second and third drawings) the skier is propelled forward by his weight; forward speed is increased by the skier’s weight and the steepness of the slope. The two main forces that reduce forward speed are the air resistance (A) on the skier and the friction (F) between the ski base and the snow. Air resistance is minimized by wearing form-fitting speed suits and aerodynamic helmets, and by an aerodynamic body position. The friction between the base and the snow is minimized by the appropriate choice of structure and wax. **So wax is a lubricant that reduces the friction between the base and the snow.**

When we’re talking about snow friction, we’re thinking of a single entity, but it’s actually the sum of three types of friction:

- Dry friction
- Wet friction
- Electrostatic friction

**Dry friction** is fairly simple to understand; it is the kind of friction you get when you rub your hands together, and it appears when snow crystals are rubbing the base.

**Wet friction** is what you get when you have a lot of water present in the snow. Threads of water called capillaries attach to the base and slow you down. You can visualize wet friction as follows: If you take two pieces of window glass, wet them and try to slide them against each other, you will notice that they stick together. Water capillaries connect the two pieces of glass so they resist separation. This doesn’t mean that water always increases snow friction. When water is present in small quantities, water droplets position themselves between the base and the abrasive snow crystals and act as lubricants.

**Electrostatic friction** is more complex than the other two, but here’s what we know: As a base moves across the snow, an electrostatic charge is created, increasing friction. A way of visualizing electrostatic friction is by thinking of “static cling.” Static electricity causes items to cling together (think of socks coming out of a dryer if you don’t use an antistatic dryer sheet). You need a force to overcome this friction in order to separate them.

To summarize, friction is the sum of three components: dry, wet and electrostatic friction. The contribution of each component to the total friction will vary according to snow conditions. On dry, very cold snow, for example, dry friction predominates, whereas in soft, wet snow, wet friction is very high. The magnitude of snow friction is influenced greatly by the snow temperature.

There is a fourth component, related but separate: **Friction due to environmental pollutants.** A base covered with sticky pollen, for example, will be slow, because of high friction between the pollen and the snow, not between the base and the snow. So friction from environmental pollutants is not included in our snow friction model, and is not present at all times, but it is very important to be aware of the effects of pollutants on friction.
Snow Friction and the Effect of Wax

The figure below shows skiing speeds for an unwaxed pair of skis at various snow temperatures and skiing speeds for the same pair of skis waxed with the optimum wax for the snow conditions.

We see that:
- Cold snow and very wet snow are the slowest, the fastest snow is at around -5°C
- Snow friction increases rapidly with colder snow, skiing on snow at -40°C is like skiing on sand
- Waxing increases speed 6% to 18% depending on snow temperatures, the higher effects are on very cold and very wet snow

The differences in speed can be explained as follows: At snow temperatures of -19°C (-2°F) there is no water present, the snow crystals are dry and abrasive (high dry friction), and electrostatic friction is high, so cold snow makes for low speeds. Early Arctic explorers reported that at -40°C (-40°F) snow friction was so high they felt they were sledding on sand. (Interesting trivia: The Celsius and Fahrenheit temperature scales coincide at -40°C.) At snow temperatures of -14°C (7°F) resistance to glide is still quite high, but the snow crystals are not so abrasive and electrostatic friction is lower, so skiing speed increases. As the snow temperature increases, water forms between the base and the snow and acts as a lubricant. This causes a significant reduction in friction compared to dry gliding. Friction is lowest, and skiing speeds highest, at snow temperatures of -5°C (23°F) to -10°C (14°F). At snow temperatures around freezing (0°C / 32°F) a lot of water is present and it attaches to the base causing a suction effect and reducing speed.
The above ski speeds are a function of the ski, skier weight, cloud cover, humidity, etc. If, for example, we use different skis or if it is sunny instead of cloudy, we’ll obtain somewhat different speeds than those shown above, but the trend will stay the same.

**Reducing dry friction**

Dry friction occurs when the base and the snow contact each other through microscopic surface irregularities called asperities. These asperities are not visible to the naked eye. The way to reduce dry friction is to use a hydrocarbon wax as a lubricant. Hydrocarbon waxes are very common and they do an excellent job of reducing dry friction.

The easiest way to visualize how a hydrocarbon wax works is to think of a deck of playing cards where the cards slide easily against each other when pushed sideways. But if something stops the cards from sliding against each other (imagine a nail piercing the cards), lubrication is lost.

Wax placed between the snow asperities and the base asperities causes the same kind of sliding, helping the base move faster on snow, while cards (i.e., wax) are left behind. Then you eventually run out of cards and you have to re-wax.

How easily these cards slide against each other depends on the friction between them. Let’s call the friction between two cards internal friction ($F_i$). Think of a soft wax, such as yellow, as a deck of small cards with low internal friction. Think of a harder wax, turquoise, as consisting of larger cards; this is shown below. It takes more effort to move the larger cards against each other, so harder waxes have higher internal friction than softer waxes.
The figure below shows a section of a ski base, waxed with turquoise hydrocarbon, moving on snow. Here we have two types of friction reducing forward movement: The internal friction ($F_I$), and the friction between the last wax “card” and the snow ($F_S$). To maximize speed we need the lowest possible sum of the two components, $F_I$ and $F_S$. Next, we see what can happen under the same snow conditions to a base waxed with yellow wax. The hard snow crystals penetrate the wax, substantially increasing the friction between the wax and the snow, while not allowing the cards to slide against each other. So although the internal friction of the yellow wax is lower than that of the turquoise wax, the higher snow friction generated by crystal penetration of the yellow wax gives a much higher overall friction, making it a poor choice for harder snow. Think back to the deck of cards model, then imagine a nail been driven through these cards; obviously, the cards cannot slide against each other with a nail connecting them. The wax must always be harder than the snow.

Although the first consideration in wax selection is snow temperature (colder snow is harder), there is another factor which cannot be ignored: the snow crystal shape.

The snow crystal chart above shows the types of new snow crystals, as these crystals age or the snow is groomed they become rounder. We see that certain shapes are much more aggressive than others: The star-shaped crystals on the left side of the chart will penetrate wax much more easily than will the rounded crystals on the right side of the chart, even if both types of crystals are at the same temperature. As the aged crystal becomes more round (less aggressive) its wax penetrating power is reduced. Therefore, both crystal shape and snow temperature are factors that determine how easily a snow crystal can penetrate wax. An aggressive snow crystal will require a harder wax than a more rounded crystal at the same temperature.

In conclusion, to reduce dry friction the following wax properties must be matched to the snow conditions:
- **Hardness:** The wax must always be harder than the snow so the snow does not penetrate it.
- **Internal Friction:** The wax’s internal friction must be as low as possible. Use the softest possible wax but it must be harder than the snow.
Reducing wet friction

We mentioned earlier that water sticks to the base (or to the hydrocarbon wax) and this increases wet friction. To prevent water from sticking to the hydrocarbon wax, we need to make it waterproof. This is accomplished by mixing into the wax a water repellent additive called fluoro, represented below by the white “cards.” We see that the water (blue) breaks up into small spheres (as it does on a raincoat) and no longer sticks to the wax when the fluoro “cards” are added. The photo below shows how water beads up on a base treated with the fluoro wax.

The more free water you have in the snow, the more fluoro you need to reduce wet friction. However, the fluoro additive also increases the internal friction of the wax, because the fluoro “cards” do not slide against the wax “cards” as readily as the wax “cards” slide against themselves. It’s therefore critical to use no more fluoro than is necessary to overcome the wet friction. Since the fluoro additive waterproofs the hydrocarbon wax but increases the internal friction, the level of fluoro is best dictated by the level of water in the snow. Using a highly fluorinated wax on dry snow reduces speed, because there is no benefit derived from the waterproof nature of the wax and the internal friction of the wax is high compared to the same hydrocarbon wax with no fluoro added.

**In conclusion, to reduce wet friction, the fluoro content of a wax has to be carefully matched to the water content of the snow:**

- If you can make a snowball that stays together use a high fluoro wax.
- If you can make a snowball that does not stay together use a mid fluoro wax.
- If you cannot make a snowball, use a low fluoro or hydrocarbon wax.

Reducing electrostatic friction

Research during the past twenty years has shown that every time a base glides on snow, an electrostatic charge is generated. The longer the glide time and the higher the speed, the more of a charge develops on the base. It has also been demonstrated that a strong electrostatic charge can increase the friction of a base on ice by as much as 50%, so electrostatic friction can reduce skiing speed significantly. The figure below shows static build-up as a function of skiing time for a base without wax, waxed with a standard hydrocarbon wax, and waxed with a DOMINATOR antistatic wax. Skiing speed for the test was a low 15 mph (24 km/h); expect much more static build-up at higher speeds. We see that static builds up slowly on the base without wax, and nearly doubles within a minute. (From other experiments we know that at high speeds it quadruples within a minute.) We also see that waxing the base with a typical hydrocarbon wax increases static build up significantly as glide time increases; after 30 seconds it starts increasing rapidly.
and at the minute mark static build-up is six times higher for the waxed base than it is for the unwaxed base. Some technicians became aware of that wax charging phenomenon through experience and observation, and would often run skis without wax in conditions where a lot of static is generated. If we wax the base with an antistatic wax (DOMINATOR Zoom Graphite), static build up over time is very similar to that of an unwaxed base. Clearly, a wax with an antistatic agent added will yield higher speeds than a wax without an antistatic agent. This difference in speed will be more pronounced at higher speeds and/or longer skiing times.

So we know that the internal friction ($F_i$) of a wax increases substantially when it becomes electrically charged. With the addition of a selected antistatic agent (shown below as a black card), the electrostatic charge decreases and so does the internal friction of the wax. Since static electricity increases the internal friction of waxes, an antistatic agent must be present in every wax or wax mixture. The type and amount of antistatic agent must be selected very carefully; many of these agents show very high internal friction when they are moving against the wax “cards.” Furthermore, new snow and old snow crystals generate static charges differently, and a number of antistatic agents show quite unpredictable performance in some snow conditions.

To reduce electrostatic friction, a carefully selected antistatic additive must be present in every wax or wax mixture.

Other snow friction factors

When wax companies develop their wax charts, they do so based on the fact that snow gets harder as it gets colder; harder waxes are required for colder snow, and softer waxes for warmer snow. While charts may work when you have pure snow, they can be very misleading in situations where the snow is affected by environmental pollution. In the example below, a hard wax resists penetration by the crystals in clean, cold snow. If, however, hard environmental pollutants such as salts or clay (represented by the red wedges) are present in the snow, the wax will be penetrated and therefore be unable to reduce friction even though it is the correct choice according to the charts. Adding a hard, extreme pressure lubricant to the wax (represented by the black cards) will provide a barrier against the hard environmental pollutants.

Dirt can also be a big problem, it acts as double-stick tape that connects the base to the snow. Let us take a detailed look at the most common environmental pollutants, how they affect snow friction, and what waxing techniques we can use to minimize their adverse effect. The following is a list of the common environmental pollutants that affect snow friction:

- Diesel exhaust from grooming machines and car exhaust from nearby highways
- Pollen from trees
- Salts and clay from the water used for snowmaking
• Hardening chemicals used by race organizers
• Specifically in Japan, volcanic ash and salt from the Monsoon snow

All of the above pollutants become a lot more evident during the spring, when a good deal of the snow has melted away but the pollutants have remained and their concentration is much greater. The correct wax choice can minimize the effects of these environmental pollutants:

Exhaust gases: These consist mostly of liquid hydrocarbons with some heavy oils and dirt dissolved in them. They are similar in chemical nature to wax, so they get absorbed by the wax and make it sticky. This is especially problematic for heavily groomed snow and for resorts that are close to highways. The absorption of oily dirt is generally reduced by the use of a fluorinated overlay or by the use of a high fluoro wax.

Pollen from trees: This is organic matter, soft and sticky, that adheres to wax and the base. It is a particularly severe problem in the spring and is generally mitigated by using a very hard hot wax. While a hard wax may initially be slower than the soft wax indicated by the wax charts, it will stay cleaner and, over long distances, be faster than a soft wax.

Salts and clay from the water used for snowmaking: The groundwater used for snowmaking often contains salt and clay that get carried into the snow. Both are quite abrasive and are attracted to the base by static electricity. For these conditions it is best to wax a little harder than the charts indicate and to use a wax containing an antistatic agent/extreme pressure lubricant.

Hardening chemicals used by race organizers: Race organizers often add chemicals (usually urea nitrate) to the snow to make it harder and safer to run a race. These chemicals make the snow extremely abrasive and damaging to the base. As with the case with snowmaking contaminants above, wax harder than the charts call for and use a wax containing an antistatic agent/extreme pressure lubricant.

Volcanic ash is formed during explosive volcanic eruptions and contains small jagged pieces of rocks, minerals, and volcanic glass the size of sand. It is extremely abrasive and conducts electricity when wet. Monsoon snow coming from the north contains a large amount of seawater so the snow actually has sea salt dispersed in it. This makes the snow crystal both drier and more abrasive than the snow temperature alone would indicate. In Japan, harder waxes with a good antistatic/extreme lubricant package, are often required for good glide.

Reducing snow friction: Summary
• Dry friction occurs when the base and the snow contact each other through microscopic irregularities called asperities. It is reduced by using a hydrocarbon wax that is just a little harder than the snow.
• Wet friction is present when threads of water called capillaries attach to the base or the wax. It is reduced by carefully matching the level of the fluoro additive to the snow humidity.
• Electrostatic friction occurs when the moving base and the wax get electrically charged. It is reduced by the addition of specialized antistatic additives to the wax.

Special cases: Friction from environmental pollutants. If environmental pollutants are present their effect cannot be ignored, and the remedy depends on the type and level of the pollutant.
4. REDUCING SNOW FRICTION: WAX TECHNOLOGY TODAY

The objective of this section is to provide some in-depth knowledge and understanding of the different types of waxes available today. This is done in simple to understand terms and does not require knowledge of chemistry and physics. It furthers one's understanding of the products available, but it is not knowledge that it is of interest to everybody. So if tech is not your thing, you can skip this section; it will not affect your ability to successfully select and apply a wax.

Hydrocarbon waxes

Until the mid-1980s, most ski waxes were relatively simple compounds called hydrocarbons, chemical formulas containing only hydrogen and carbon atoms. They are low cost commodity products derived from crude oil (natural waxes) or coal (synthetic waxes), and they are available in a variety of hardness grades.

Hydrocarbon waxes are made up by connected hydrocarbon building blocks. Think of the circle below as the basic hydrocarbon block.

![Basic Hydrocarbon Block]

These blocks can be connected to give linear waxes called **paraffins**

![Linear Waxes]

or branched waxes called **microcrystalline**

![Branch Waxes]

Paraffins are hard and slippery and are the main components of hydrocarbon waxes. Paraffin waxes have relatively large brittle crystals (macrocrystalline) and generally have little affinity for oil.

Microcrystalline Waxes have very minute crystals (micro crystals) and are flexible, with a greater affinity for oil, which is held tightly in the crystal lattice and does not migrate to the surface. Microcrystalline waxes are tacky and not slippery, they are sometimes used in small quantities to make waxes more durable.

Both paraffin and microcrystalline waxes are biodegradable, non-toxic products. Food and pharmaceutical grades are also available: Vaseline is a microcrystalline wax, baby oil is a paraffin, and solid paraffins are used in some medications.

Hydrocarbons can either be natural (derived from crude oil), or synthetic. In the hydrocarbon formula below, \( x \) means that an \( x \) number of building blocks are connected together in a straight fashion. The properties vary significantly with the magnitude of \( x \):

![Hydrocarbon Formula]

For \( x \) values up to 2, the hydrocarbons are gases. For example, if \( x=1 \) (three building blocks) we have propane. For \( x \) values up to 17, the hydrocarbons are liquid and the higher the number, the thicker the
liquid. For example in gasoline (a hydrocarbon) the average x value is around 6 and for baby oil (another hydrocarbon) it is around 16. Higher x values represent solid paraffins. As the number of building blocks gets higher the paraffins become harder and melt at higher temperatures. IT IS IMPORTANT TO UNDERSTAND THAT THE PARAFFINS USED IN WAXES ARE NOT SINGLE COMPONENTS, BUT BLENDS. In a soft wax x is 18, 19, 20, 21, 22, 23, 24, 25 and 26 so it is a blend of nine waxes and the average x is around 22. In a hard wax the average x is 30 and in a super hard synthetic wax the average x is 50. As the x value gets very high the hydrocarbon changes from wax to plastic. This plastic is called polyethylene, or P-tex (yes, the ski base material is a hydrocarbon). In extruded polyethylene x is 40,000 and in sintered polyethylene x is 200,000 so we see than even in the plastic form more building blocks mean a harder material.

**Delivering wax to the base**
The polyethylene base is made from hydrocarbon building blocks. If the blocks are connected linearly, the chains pack very closely and the polyethylene does not absorb wax. This is called a crystalline region.

![Crystalline region](image)

If there is some branching the chains are not packed very closely and there is some room between them for wax to be absorbed. This is called an amorphous region.

![Amorphous region](image)

(The building blocks for the polyethylene and the paraffin are the same; we used different colors to make paraffin and polyethylene easier to distinguish visually.)

Another way to visualize this is to think of the crystalline polyethylene as uncooked spaghetti that packs very closely, and the amorphous polyethylene as cooked spaghetti that has these empty spaces where wax can fit. Both crystalline and amorphous regions are present in a base, around 50-50 in a competition grade base.

These are the key concepts:

- Wax can dissolve in the amorphous polyethylene regions as sugar dissolves in coffee. It does not go in the holes of the base as is stated in some manuals.
- More heat and more time means that more wax dissolves in the polyethylene until you reach the maximum capacity.
- When the base heats up it absorbs wax; when it cools down it expels wax.
- Softer waxes have lower melting points and are smaller in size, so they dissolve more easily and penetrate deeper than harder waxes.

Hot waxing is the most common and effective form of delivering wax into the base. In this type of application, the wax is melted and applied onto the base by ironing. The heat from the iron melts the wax and increases its solubility in the amorphous polyethylene channels. Gravity forces the molten wax down into the channels. This solubilization (dissolving) of wax in amorphous polyethylene is a reversible process and depends on temperature. When the base is heated up, wax is absorbed; when it cools down, wax is “squeezed” out. The sequence below describes what happens when wax gets ironed into the base. The ruler marks show the thickness of the wax layer on the base:
Step 1. Cold new base without wax
Step 2. The wax is ironed in and dissolves in the amorphous polyethylene
Step 3. The base cools to room temperature and some wax comes out
Step 4. The base cools on snow and more wax comes out

**Delivering wax to the base: The time element**
Sufficient time must be allowed between ironing and scraping: When the wax is melted (liquid), the cards are in random positions, away from each other. As the wax cools and solidifies, the cards are on top of each other but they are not stacked well and internal friction is high. After some time the cards organize themselves to the tight deck and the minimum internal friction. The cooling must be slow, if it happens too quickly (like taking a warm ski outside) the cards freeze in a position that has higher internal friction. Typical “cooling” times between ironing and scraping are overnight for very soft waxes, three hours for normal (pink, universal) waxes, one hour for cold range waxes, and around 15 minutes for extreme cold waxes. If sufficient waiting time is not available, paste or rub-on waxes are the best options.

**Fluorocarbon waxes**

*In the mid-1980s, fluorocarbon waxes (also known as perfluoroalkanes because they contain only fluorine and carbon atoms) were developed. These waxes are applied over hydrocarbon base waxes and offer outstanding performance on wet and relatively new snows, which is attributed to their high degree of water repellency and very low friction coefficient. They also resist oil and dirt, which is attributed to their high degree of oil repellency and very low friction surface energy.*

Think of the blue square below as the basic fluorocarbon building block. Fluorocarbon snow waxes are made up by connecting around 20 fluorocarbon building blocks.

These fluorocarbon chains form a very tight “fence” that water and oily dirt droplets cannot penetrate. The
internal friction of this “fence” is extremely low making the fluorocarbon waxes excellent lubricants.

Bases treated with fluorocarbon wax are “self-cleaning“: Oily dirt and water do not stick to the base and as the water rolls off the base it carries the dirt with it.

Fluorocarbon waxes do not mix with hydrocarbon waxes or with polyethylene, so when applied to the base they stay on the surface.

Advantages
- Outstanding performance on wet and relatively new snows
- Very fast on dirty snow

Disadvantages
- They do not mix with hydrocarbon waxes and are used only as overlays
- They do not last for long distance
- They are too soft and do not work well below -5°C (23°F)

Fluoro waxes

Fluorinated paraffins (or fluors) became available around 1990 and their main function is to repel water. Wax manufacturers blend fluors with warm or cold hydrocarbon waxes to produce waxes in a variety of fluoro concentrations and hardness grades. Depending on the amount of fluoro they contain, these waxes are categorized as low-fluoro, mid-fluoro, or high-fluoro. Fluors are very expensive, so the more fluoro you add to the hydrocarbon wax, the more expensive the wax becomes. Low-fluoro waxes cost three times more than hydrocarbon waxes, mid-fluoros five times more, and high-fluoros ten times more.

Hybrid fluorinated additives (often called fluors) are formed by combining hydrocarbon and fluorocarbon building blocks in a specific order and ratio. These fluors stack like cards.

The hydrocarbon segment of the fluoro makes it possible to mix a fluoro with a hydrocarbon wax; it also allows it to have some penetration into the base. These are major advantages compared to the fluorocarbon waxes. The fluoro-hydrocarbon wax blends are called fluoro waxes.
The fluorocarbon segment of the fluoro helps anchor fluorocarbon overlays on to the fluoro wax. So these overlays are more durable applied over a fluoro wax rather than applied over a hydrocarbon wax.

Fluoro waxes have better water repellency than hydrocarbon waxes because of the fluoro segments they contain, which sit on the surface of the wax and form a barrier against water.

**Antistatic and extreme pressure additives in waxes**

Over the years, most wax companies have made “antistatic” waxes by mixing extreme pressure lubricants such as graphite, molybdenum disulfide, and other “secret” ingredients into hydrocarbon or fluorinated waxes. Performance of these waxes, however, is often unpredictable, and guidelines as to when and how to use them are murky.

Four types of compounds are commonly used as antistatic additives for waxes: Graphite, molybdenum disulfide (moly), tungsten disulfide and fluorographite. All are considered extreme pressure lubricants, often used in high load metal-to-metal lubrication. They are extremely hard and are not penetrated by the hardest snow crystals or even by snow impurities like clay or salt, so they are very useful on aggressive and polluted snow. They all have low internal friction (some lower than others), because of their layered structure. Their interaction with snow varies wildly with different types of snow crystal; this is very complex science requiring a good grasp of the concepts at work, so antistatic wax additive science is poorly understood, even by many wax companies.

The concepts at work are very advanced but here is an oversimplified way of looking at the situation: Think of snow crystals as having a very weak magnetic field, and of each crystal shape as having a different type of field. Think of the lubricants (graphite, moly, tungsten disulfide, etc.) as having their own unique magnetic fields. The way the snow crystals and the additives approach each other determines whether their “magnetic fields” attract (this increases friction) or repel (this reduces friction) each other. The complexity of the situation is illustrated in the case of graphite, below:

At the molecular level, all graphite types are the same, they are layered structures as shown on the left. Think of these layers in terms of the deck of cards example we used before; this graphite deck cannot be pierced by hard snow crystals or impurities. These layers are not visible to the naked eye or even through a very strong microscope. The photo on the right is a photograph of graphite; to the naked eye all types of graphite appear the same. The center photo was taken using a microscope, and it shows how molecules of graphite pack together; this is the key to the puzzle. Graphite molecules can pack together as rods, plates, spheres or needles. The sizes of each shape vary, from under a micron to tens of microns. Each shape interacts differently with each type of snow crystal so it may reduce friction on one type of snow, but increase it on another. Snow temperature also plays an important role, so the effect of the additive on snow friction may depend on the temperature. As an illustration, in the DOMINATOR line we use a very specific form of graphite as an antistatic/extreme pressure additive in our fresh snow waxes. It is a custom blend of two shapes, each in its own specific size; if we change one of the variables, the additive is no longer effective. For extremely cold snow, we use the same shapes, but in different proportions. For old snow we use a different antistatic package based on Fluorographite polymer. For the very unique snow conditions in Japan, we use tungsten disulfide. These waxes have been the result of sophisticated computer-aided experimental design, research work in state-of-the-art laboratories, and extensive on-snow testing. As a result of this pre-launch work, there are very specific instructions on when to use which DOMINATOR antistatic waxes and these formulations have been successful for many years, with only some minor evolutionary adjustments. No other wax company can make this claim.
5. THE THREE STEPS OF COMPETITION WAXING

There are three distinct steps in competition waxing:

1. Base preparation: This is done in the waxroom, its purpose is to clean and condition the base, and base prep wax choice is independent of the snow conditions.

2. Application of glide wax: This is done in the waxroom, its purpose is to increase glide speed, and wax choice depends on expected snow conditions.

3. On-hill application of no-iron waxes and overlays: This is done at the competition site, its purpose is to increase glide speed, and wax choice depends on actual snow conditions.

Base preparation
This is done in the waxroom, and is independent of the snow conditions. Base prep waxes clean the base by removing dirt and old wax from the surface and the amorphous polyethylene channels. Why is this necessary? Clearly the dirt needs to be removed, unless the old glide wax is removed, it will mix with the newly applied wax and change its properties. There are several approaches to base preparation: Some companies recommend a hot-scrape with their softest hydrocarbon wax to clean the base, followed by a number of conditioning steps using a hydrocarbon or low fluoro wax matching the expected snow conditions. Other companies have base prep waxes that match the expected snow conditions. The DOMINATOR RENEW base prep is independent of the expected snow conditions. It is a blend designed to clean the base and remove the old wax, while leaving a surface layer that does not impact the properties of the glide wax to be ironed in later. After conditioning the base with RENEW, the composition of the wax left in the base changes as you go from the core of the polyethylene to the surface, this is called a gradient. This gradient increases the elasticity of the polyethylene and the adhesion of the glide wax near the surface of the base. This is the reason RENEW increases speed and durability compared to traditional base preps.

Application of glide wax
This is done in the waxroom and the choice of wax depends on the expected snow conditions; it maximizes speed by reducing snow friction.

Glide waxes are typically chosen from each company’s waxing charts. To use these charts effectively, one needs to know the snow temperature, sometimes within two degrees, the snow crystal type, and the relative humidity. There are four common errors and misconceptions:

- “Wax for the flats, they are the most important places to go fast.” You hear this often, but it is wrong; you should wax for the coldest part of the track or you will be very slow there.
- “Air temperature and snow temperature are close enough.” This is one of the best ways to miss the wax; air temperatures can vary as much as 15°C from snow temperatures. Use snow temperatures.
- “You can choose fluoro levels based on air humidity.” This can also be very misleading; you can have dry snow and high air humidity, and vice versa. Use snow humidity instead: If you cannot make a snowball the snow is DRY; if you can make a snowball but it does not stay together, the snow is NORMAL; if you can make a snowball and it stays together the snow is WET. Wear gloves when you make a snowball.
- “If you are waxing for parallel format, skicross, boardercross, or halfpipe, wax harder because the wax has to last for multiple runs.” If you wax too hard, you may not qualify so subsequent runs are a moot point. Choose the ideal wax for the conditions and refresh between runs either by rubbing a wax bar on the base, or by using a paste wax.

There are four often-ignored factors influencing wax choice:

- When in doubt, wax harder.
- If the night is clear, the snow will be very aggressive early in the morning. This happens because some snow melts (it can even evaporate) and re-freezes into sharp crystals. Go with the harder wax option.
- Always ask if they are making snow on the competition area. If they are, go with the new snow formula.
- If the slope faces north or west, the snow temperature does not change much from morning to noon, even if it is sunny. The opposite holds if it faces east.
On-hill application of rub-on waxes and overlays

This is done a bit before start time, and choice depends on actual snow conditions. Its purpose is to work together with the previously applied hot wax to increase speed and wax durability, or to adjust the previously applied hot wax to deal with unexpected snow conditions. We use two types of on-hill waxes:

1. Rub-on waxes and race pastes: Any glide wax that can be rubbed on and brushed out to modify the properties of the hot wax. Durability will be limited, but may be enough for the event. Pastes must be allowed sufficient time to dry (typically around five minutes), before brushing out.

2. Premium overlays (pure fluoro blocks): Their main usefulness is on wet or dirty snow. The fluorocarbons have a lower temperature limit of about -10°C (14°F). Newer technology fluoro blocks can go down to -15°C (5°F), depending on how aggressive the snow is.

There are five main situations where on-hill application is useful:

1. The wax is too soft for the conditions. The base feels a bit sticky and it gets a little better as the speeds get higher. At colder snow temperatures you also see snow sticking to the base. Remedy: Rubbing a wax for the correct temperature improves glide.

2. The wax is too hard for the conditions. Initial acceleration is great, but the ski does not go fast, it’s like staying in third gear in your car with two gears to go. Remedy: Rubbing a wax for the correct temperature improves top speed.

3. The wax is right for the conditions but there is no antistatic additive (or the wrong antistatic additive). The base feels quick initially but it starts to slow down gradually (e.g. towards the end of a downhill) even though the snow conditions are not changing. Remedy: Rubbing a wax with the right antistatic additive improves the speed profile.

4. The base has the correct wax but it is depleted and there is no time for hot waxing. Remedy: Rubbing the correct hot wax will keep the base from drying.

5. The wax is right for the conditions but we want to improve glide even further. Remedy: Use overlays, for example, a 100% fluoro block for wet snow.

When rubbing waxes, keep in mind it is a surface treatment so it does not last long; refresh as needed.
6. EPILOGUE

There are many components to ski and board preparation, and it is extremely difficult, if not impossible, to succeed at the highest level if you don’t master all of them. Bevels control the ability to turn, base structure and wax control the speed, and this is before you consider the binding and the boot. Among these components, wax is thought to be the most mysterious and difficult to master.

Demystify: de-mys-ti-fy /diˈmɪstiˌfai/ verb (used with object), to make (something) clear and easy to understand: to explain (something) so that it no longer confuses -- Merriam-Webster Dictionary

With the information presented here, you’re well-prepared to approach waxing with a new understanding of exactly what’s happening when your base hits the snow: It’s science, not alchemy. So take a fresh look at your wax box and put that science to work for you.