Lean Flow Management for Production Efficiency©

Scott Epps
Hoffman Nursery, Inc., 5520 Bahama Road, Rougemont, North Carolina 27572
Email: scottepps@hoffmannursery.com

INTRODUCTION

Waste creates problems. It expends resources, frustrates those involved, and adds unnecessary costs to the process. An operational strategy called Lean Flow aims for a solution to these problems — it focuses on reducing or eliminating waste so that fewer resources are needed to do the same or more work than before. Within Lean Flow Management, waste is identified as anything the customer is not willing to pay for, including wasted time, effort, money, movement, and materials. The goal of the system is to provide the customer with the highest quality at the lowest cost with the shortest lead time.

Lean Flow strategies include reducing lead time and inventory, introducing quality checks into processes, and finding better ways to manage work flow. This focus on processes makes Lean Flow heavily dependent on employee involvement. Lean Flow or Lean Manufacturing evolved from the Toyota Production System. Although it originated in the manufacturing realm, the concepts can be applied to all sorts of businesses and operations such as office operations, academia, and retail establishments.

WHY LEAN FLOW?

At Hoffman Nursery, Inc. (HNI) we were in the process of upgrading our production facility with a new building and new equipment. We knew that changes in the building and the equipment would improve production, but we suspected that changes in the processes and in our employees' mindset could improve efficiency and quality as much, if not more, than the physical changes. We believed Lean Flow could help us accomplish two specific aims: (1) Improving efficiency for better production yield and increased crop turnover, and (2) Improving liner quality by producing a more consistent, uniform product. The most compelling aspect of the system was its potential to help us give our customers the highest quality product at the lowest cost in the shortest amount of time. This, in turn, would make us more competitive in the wholesale nursery market.

WASTE (*MUDA*) AS A KEY CONCEPT

One of the key concepts in Lean Flow is identifying, reducing, and eliminating waste (*muda* in Japanese). To illustrate, consider the human motion in a production process. It can be classified into three types: actual work that adds value to the product; auxiliary work, which is motion that supports actual work; and motion that creates no value and if stopped would have no negative impact on the product. In this case, the latter motion is considered *muda*.

The system divides waste into seven categories:

1) Over-production: Creating product that does not sell. This is one of the worst forms of waste because it creates other forms of waste.
2) Inventory: Excess materials, parts, and work in progress are considered waste. Keep inventory at an absolute minimum.
3) Motion: Unnecessary movement of employees.
4) Delay or Waiting: Interruption in the flow caused by waiting for materials or products. Line stoppage.
5) Transportation: Unnecessary movement of materials, which adds no value to the product.
6) Over-processing: Doing more than is necessary.
7) Correction or Rework: Defective products use existing resources and fixing them requires additional resources.

ESTABLISHING A LEAN FLOW WORKPLACE

A Lean Flow workplace depends on stability in the 4 Ms, which are Man/Woman, Machine, Material, and Method. To create stability, the workplace environment must be self-explaining, self-ordering, and self-improving. Interrelated systems within Lean Flow, including Visual Management and the 5S system, support this state. Visual Management makes it easy to see what is out of place and makes waste obvious so it can be easily spotted and addressed. The 5S system establishes a workplace where Visual Management can operate.

The 5S system to establish a stable workplace consists of five steps: Sort, Set in order, Shine and inspect, Standardize, and Sustain. Sort refers to getting rid of what you do not need. Unnecessary tools, machines, chairs, and other items can impede the flow of materials and consume potentially valuable space. The next step, Set in order, refers to organizing remaining items to reduce the seven categories of waste. The goal of this step is to create an environment that talks to you. Colors, shadow boards, signage, and maps indicate where items are located, what needs to happen, and how it needs to happen. Shine and inspect follows from organizing the workplace and supports stability. It defines what needs to be cleaned, how it should be cleaned, how often, and who should do the cleaning. It also includes scheduling regular equipment inspections.

Once the first three steps in the 5S system are complete, it is important to define standards for the system. Standards explain all aspects of the workplace (e.g., where pruners are stored, all hazardous areas are marked with yellow tape, the cleaning protocol for bench areas, etc.) and help make out-of-standard conditions obvious. The system now results in a clean, lean, well-organized workplace. The next step is to sustain what has been created though regular promotion, communication, and training. Keeping employees involved and engaged is critical to sustaining the system.

IMPLEMENTING THE SYSTEM AT HOFFMAN NURSERY, INC.

At HNI we have clearly marked workstations and designated places for all equipment, including personal protective gear and first aid supplies. Employees do not waste time searching for a tool or equipment. Work areas are divided into zones, and individual employees are assigned responsibility for cleaning each zone. At the end of the day, employees return all supplies and equipment to their designated

places, leaving each area ready for the next work day. Employees know exactly what is expected of them because work-zone standards are set and visual diagrams show exactly how each workstation should look after cleaning. Clean, well-maintained machinery and equipment lasts longer, and clean workspaces create a safe environment. We also use color as visual aids. Boundaries, including work areas and spaces set aside for boxes, supplies and equipment, are marked with blue tape; red tape indicates danger; green is for first aid; yellow is a signal for caution.

OPTIMIZING THE PRODUCTION PROCESS

Once you have implemented the 5S system and Visual Management can be applied, it is time to analyze the processes that go into creating the product. This phase involves differentiating production into process units and identifying how the units relate to one another. Flow charts are a good way to visually map the relationships among the processes. This also helps with an important part of the analysis — identifying areas of waste such as unnecessary human motions caused by steps being too far apart or unnecessary movement of materials.

Once individual processes are identified, each is broken down into systematic steps or Standard Operating Procedures. At HNI we create a Standard Operating Worksheet (SOW) for each process identified in our flow charts. The SOW tells employees the work content, the sequence to follow, when quality checks are needed, and the personal protective equipment required for the job. SOWs are useful for identifying areas that do not add value to the product. We constantly refine the processes as we discover new ways to minimize movements or improve procedures. In addition to the written SOWs, visuals are created to illustrate the process steps and to indicate standards. For HNI and Lean Flow, consistent quality is a major concern, so we created signs with photos indicating the standard division size for each of our plants. The production employees know what size to make the division because the visual aid is posted in the splitting/grading area. We use visuals throughout our production area to illustrate standards to our employees. The visuals help reduce the waste of correction and rework. We also have visuals illustrating plant diseases and insects to watch for and visuals indicating the correct planting depth.

Production planning is important in Lean Flow, and accurate information is crucial to good planning. Inaccurate information leads to poor planning, which leads to waste in the system. To help with planning and analyzing processes, it is important to know the time needed to perform each step in the process. At HNI we timed how long it took to complete each process. This required numerous time tests to determine average times for the different processes and different groups of plants. However, it gave us valuable information for improving procedures and movements, thereby eliminating wasted time and energy.

To be successful with Lean Flow, employee training and involvement is crucial. Well-trained employees know what to do and when to do it without waste. At HNI our employees are trained on a main task and the tasks that come before and after it in the process. This gives flexibility during the work day, with employees moving (“flexing”) up or down to a different task in the process when necessary. SOWs and visual aids facilitate training and serve as references once employees are certified on their tasks. Employees are also trained to keep the process flowing. Lean Flow is organized around the pull system, which supplies only as much product as is needed. No surplus is produced because it results in and is considered waste.

In an operational setting, supplies, raw materials, and finished goods are pulled through the system through a series of in-process *kanbans* (IPK). These are signals for employees on what action needs to be taken. The IPKs help prevent buildup of inventory and over production. At HNI we use IPKs to visually communicate to employees when to flex up or down. For example, in our trimming process we have blue baskets that are filled with trimmed plants. When all the baskets (*kanbans*) are full, the trimmers flex up to help in the splitting process. In an example from the potting process, colored trays indicating grade A and grade B divisions are filled with divisions ready to pot. When the *kanbans* are full, it signals to the employee in splitting to flex up and help in potting. Our IPKs result in less wasted time and allow employees to know what to do without being told.

Customer demand drives the Lean Flow system, which strives to produce what is needed, in the right quantity, at the right time. This concept, referred to as "Just-in-Time" production, is supported by IPKs and reduces in-process inventory. Excess inventory refer not only to finished product growing in greenhouses, but also to raw materials, plants waiting to be processed, and anything that has to be cared for and stored. At HNI we have changed from bulk ordering and maintaining excess inventory to inventorying just what is needed. This results in fewer damaged materials, lower space requirements, reduced materials handling, and reduced cash outlay. Perhaps most critical is learning to produce the right amount of plants. Over production leads to discarding plants that are too old, overgrown, and out of line with quality standards, which becomes very costly. Just-in-time production is a challenging concept that is difficult to implement and sustain. However, if done successfully, it will pay off with greater returns.

At the heart of any successful lean system is continuous improvement or *kaizen*. Continuous improvement must be embraced by everyone from top management down to the general labor. Employees need to be given opportunities and the power to improve the processes and their work areas. Continuous improvement is not necessarily about major changes. Rather, it embraces small, meaningful changes that over time improve processes and eliminate waste. Continuous improvement also promotes employee satisfaction and helps the organization grow.

CONCLUSION

Lean Flow is a business philosophy that seeks countermeasures to problems and waste that impact all kinds of businesses. For Lean Flow implementation to be successful, it must be embraced by everyone involved in the organization. At HNI, the process has taken time, focus, and dedication. We can report that we have seen reduced waste in all areas of production, our employees are better trained, our product is more consistent, and we have a better grasp on handling what lies ahead. Lean Flow is not a quick fix, but rather a long-term strategy that can make an organization stronger, more efficient, less wasteful, and more equipped to handle the fluctuations of customer demand.

The Basics of Grafting©

Brian Upchurch
Highland Creek Nursery, 269 Drake Farm Road, Fletcher, North Carolina 28732
Email: highlandcreeknursery@gmail.com

INTRODUCTION

Grafting ornamental plants carries with it a mystique and perception as one of the more difficult forms of plant propagation. While it can be difficult at times, successful grafting is usually predicated on a solid understanding of the basics, coupled with considerable practice.

My goal here is to discuss the basic steps and concerns relating to grafting woody ornamental plants. Grafting, much like other forms of plant propagation, begins with a simple recipe. The recipe serves as a guideline; however, each grafter must adapt the recipe to serve his or her specific needs and objectives. This recipe will, more often than not, blend aspects of both science and art to achieve the desired result. Propagation includes the sciences of botany and plant physiology, as well as artistic skills honed by practice and experience over time. A grafter must follow the science of horticulture to provide the necessary elements and conditions for plants to grow and thrive. For example, he or she must also be an artist in the sense that each different plant requires fine tuning the recipe to adjust for different conditions and objectives.

The single objective in grafting is to combine a rootstock (root system) with a scion piece (shoot system) from the desired "mother" plant — and have the resulting plant grow as one. This seemingly simply activity has several elements critical to success. The most important ingredients of the grafter's recipe are: (1) a vigorous and healthy rootstock, (2) a vigorous and healthy stock plant, (3) sound grafting technique, and (4) proper aftercare of the completed graft. If the grafter is diligent in combining these four basic ingredients, then grafts will be successful.

ROOTSTOCK

The first consideration of grafting woody ornamental plants is the rootstock, occasionally called understock. The rootstock will become the root system and the foundation of the subsequently grafted plant. The rootstock and the scion, which will become the top portion of the plant, must be compatible. Compatibility in the strictest sense means that the scion and rootstock are related closely enough that the graft union will callus, heal, and continue to grow as one plant. If the rootstock is not compatible with the scion, the graft union will fail to heal, and the plant will die. It is also possible that the graft union may heal initially, but fail at some point in the future. This failure can occur quickly, or in some cases, may take years.

Some "compatible" rootstock and scion combinations are better than others. In general, the scion and rootstock must be the same genus and species. As a plant propagator, one must be aware of the benefits and limitations of a given combination. Some rootstocks may be compatible, but are poor choices nonetheless. Suckering may be a problem with a rootstock, or perhaps the scion will under or overgrow the understock, causing an unsightly graft union. For example, *Corylus avellana* cultivars can be grafted reliably onto *C. avellana* seedlings. The combination is

compatible, but *C. avellana* rootstocks will sucker unmercifully, causing incessant maintenance issues for the life of the plant. *Corylus colurna* seedlings also provide a compatible rootstock for *C. avellana* selections. However, this combination also has limitations. *C. colurna* seedling rootstock will overgrow the scion, sometimes causing an unsightly graft union. Under or overgrowth of the rootstock or scion may simply pose an aesthetic problem. It may also cause structural or functional problems. Some rootstock choices may tend to reduce the vigor of the scion, which may or may not be desirable. Other rootstock/scion combinations may heal and seemingly grow properly, but the rootstock may anchor into the soil poorly. Other rootstock concerns may be cold hardiness, heat tolerance, and drought or moisture tolerance. Availability and/or cost of a particular rootstock can also be a concern to the propagator. All of these issues should be considered when choosing the best rootstock for grafting the desired plant.

There are some exceptions to the "same genus, same species" rule for compatibility. For example, *Acer rubrum* cultivars grafted onto *A. rubrum* seedlings are incompatible over time. The graft union will heal, but tends to fail within several years. There are also no cultivars of *Quercus rubra. Quercus rubra* scions grafted onto *Q. rubra* seedlings will not survive; and propagation by rooting cuttings for these plants is extremely difficult. The converse is represented as well. Within the same genus, there are combinations utilizing different species. *Acer griseum* can be successfully grafted onto *A. saccharum. Cornus florida* and *C. kousa* may be grafted onto each other. *Coyruls avellana,* as mentioned above, works with *C. colurna*, and *Hamamelis* species are compatible with other *Hamamelis* species (although some choices are better than others with regard to suckering).

It is also possible in some cases to cross over to a different genus within the same family. For example*, Hamamelis* species and cultivars can be successfully grafted onto *Parrotia persica*, and *Fothergilla* species and cultivars are also compatible with *Parrotia persica. Chionanthus virginicus* is reportedly compatible with *Fraxinus ornus* and *F. excelsior*, although long-term compatibility is questioned (Dirr, 2009). Barnes (2008) recently reported that *Pinus strobus* seedlings serve as a suitable understock for *Cedrus atlantica* cultivars. Grafters are well advised to consult other grafters, seedling vendors, trade journals, and other references to determine the best options when considering grafting compatibility. It is extremely important that grafters recognize the benefits and limitations of grafted plants — keeping the ultimate consumer in mind. Grafted plants that subsequently fail or produce suckers present an inferior product to the end user.

In addition to being compatible with the scion, the rootstock must be healthy and vigorous. This cannot be overstated. Any stress on the rootstock will adversely affect the subsequent graft. I am amazed how poorly rootstocks are treated in some nurseries; and the grafters wonder why grafting success is so elusive and/or inconsistent. These plants must benefit from proper growing conditions, like any other crop in the nursery. They require a proper soil mix, adequate water and nutrients, and to have any pests controlled as needed. This requires planning. The grafter must know in advance which rootstocks will be needed at grafting time. Therefore he or she must grow them a year or more in advance; or acquire them at sufficient size just prior to grafting.

I have found that for the best results, it is best to use established rootstock when grafting. Rootstocks that have been bare-rooted just prior to grafting are under

stress, and may yield inferior results. I order seedlings from my vendors a year or more before I will need them. They are typically received in February, potted into the appropriate size tree bands, grown that season in the nursery, and then grafted that summer or more likely the following winter. The rootstock is in my nursery for 10–12 months, allowing me to control the soil mix, pot size, water, nutrients, pest control, shade, and other aspects of production. Again, it is very important to tend the rootstock throughout the growing season to ensure quality and vigor, while minimizing stress.

After several years' experience, I have learned which size seedlings to order from my seedling vendors to ensure that I will have the correct size rootstocks when I am ready to graft. My goal is to have an established, well rooted rootstock comparable in size to the scion I will be grafting.

STOCK (MOTHER) PLANTS FOR SCION PRODUCTION

The stock plant is an equally important ingredient of the grafter's recipe. The scion piece taken from the stock (mother) plant will become the top, above ground portion of the grafted plant. It is important that the scion be healthy and vigorous. A healthy stock plant will usually provide quality scions**.** Like rootstocks, stock plants should be grown and maintained in the nursery to optimize vigor and health. This means superior growing conditions, adequate moisture and fertility, and measures to control any pests and diseases present. The goal is to minimize plant stress. Older or stressed stock plants will provide inferior scion material, and will adversely affect the graft quality. Plants not maintained specifically for stock, often provide inferior scions. The best way to ensure consistent, quality scion material is to maintain your own stock plants for this purpose.

Another considerable advantage in maintaining one's own stock plants is having access to "true-to-name" scion material. Unknown and mislabeled plants are persistent in our industry. Too often, plants of dubious or unknown origin are propagated, perpetuating the problem. If the name of a plant can be verified, it can be advantageous to dedicate sufficient plants and space for use as stock plants. I have found that plants in gardens (both public and private), arboreta, and in nurseries are often mislabeled. If the correct name is even remotely in question, it should not be propagated. Grafters must be extremely diligent in this realm. It is our responsibility as propagators to keep cultivars clean and true to name. We do a disservice to the industry and the end consumer if we are not extremely careful in this aspect of propagation.

At the time of grafting, the stock plant, and in turn the scions, should be dormant. This allows the graft union to heal, or callous, before the scion breaks dormancy. If the scion becomes active and tries to push new growth before the union has healed, it will fail because there is no path for water and nutrients to pass from the rootstock to the scion. If the grafting is done during the winter months, this presents no problems. Scions should be cut when temperatures are above freezing. The sooner the scions are grafted, the less likely it is that they will be exposed to problematic conditions, such as desiccation. If they are to be stored for any length of time; scions should be labeled, refrigerated above freezing, and kept reasonably moist (but not wet). The goal is to prevent desiccation, but avoid rotting. Mold is a concern, so use of fungicide is advisable if storage for more than a week or two is anticipated. If you use a household refrigerator, keep in mind that most newer units are "frost free";

and the air in them tends to be very low in humidity. Scions will deteriorate rapidly if not checked frequently, and high moisture levels maintained. Under ideal conditions, scions may be stored up to 4–5 weeks. The quality will decline rapidly beyond this time frame or under less than ideal conditions.

If the grafting is done during the summer months, the scions should be collected after the most recent flush of growth has hardened off and the terminal buds have been formed. I collect them in the morning, and graft before the heat of the day. My experience with summer grafting is limited, but I would venture that short-term storage of scions is possible in a cool, damp environment. However, I think long-term storage would be risky at best.

Scions should be collected from the most recent season's growth. I cut all of a new shoot from the stock plant, leaving only a pair of buds in the case of opposite buds, and one or two buds if the buds are alternate. This hard pruning will provide the largest, most vigorous scions for grafting, and also ensure heavy new growth for the following year's grafting. If scion material is smaller than desired or otherwise inferior, do not hesitate to go into second-year wood. The larger size of the second-year wood scions often trumps smaller, first-year cuttings that may prove inferior. When collecting scions, it is sometimes difficult to ascertain if the wood has hardened off completely. This is especially true of smaller scion material on older plants. Second-year scions can mitigate this problem.

GRAFTING TECHNIQUE

The primary concern when grafting is to optimize the cambium to cambium contact between the scion and the rootstock. The exposed cambium layer on the scion and rootstock is thin (only a few cells thick), so it is important to align the scion properly with the rootstock, and to ensure maximum surface to surface contact at the microscopic level. The first aspect is achieved with repetitive practice cutting scions and rootstocks, and the second goal is met by using a sharp knife.

It is difficult to teach the actual grafting technique with written or even visual instructions. The goal is to make a clean, uninterrupted cut. Ideally, the grafter will learn this from another grafter, with sufficient time and practice available to master the process. When teaching others to graft, I have found that I can show the student the cutting motions and the desired result, but they must ultimately learn how to handle the knife and achieve the desired result with their own unique motion and technique. Each grafter I have observed seems to have a slightly different technique of cutting the scion and rootstock, while achieving comparable end results. I strongly recommend that the prospective grafter find a mentor to work with, as grafting takes much practice, and the many aspects of grafting, with regard to before and aftercare, can be best discussed and understood while working side by side.

In addition to the mechanics of grafting, the grafter must learn to properly sharpen their knife. This is indeed an art. It takes time and practice to learn to do it properly so the edge remains sharp and the angle consistent. I discourage the use of one knife by more than one person, as each may sharpen the knife at a slightly different angle, and the "feel" of the knife may change. Grafting knives are beveled on one edge, unlike most pocket knives which are beveled on both edges. For this reason, left and right handed knives are available. Carbon steel knives are somewhat easier and quicker to sharpen, but tend to dull more readily. Stainless steel

knives maintain the edge longer, but may be more difficult to sharpen initially. I have found Tina brand knives to be superior to others, and they offer much more comfortable wooden handles as an added benefit. Victorinox offers excellent stainless steel knives; however, the plastic handles tend to be less comfortable. I use a Tina 605 and Tina 606 for bench grafting, and a Victorinox for T-budding and chip budding in the field. I have also known of grafters using single-edge razor blades and hobby knives which are disposable or have disposable blades respectively. Ultimately, the individual must decide which is best for the given application.

The type of graft used will depend on the plant and the grafter's preference. The modified side veneer graft has become more popular in the last decade or so, and for most deciduous woody plants, it is now the graft of choice. The traditional veneer graft is usually the first choice for conifers. Again, the prospective grafter will benefit from learning the specifics from an experienced grafter rather than text with or without photos.

Longer stem cuttings produce multiple scions. The stems are usually cut into individual scions each with two sets of buds if opposite and two to three buds if the bud arrangement is alternate. Dwarf or more compact plants with close internodes may have multiple buds on each scion. Larger scions will produce more vigorous grafts. This is due primarily to the ability to use larger rootstocks. The larger scions will come from the base section of the stem cutting obtained from the stock plant. Although the graft may be more vigorous, the plant may require pruning and/or staking in the first year to maintain a single stem. This is because the large, basal scion has been cut, essentially removing the leader and forcing lateral branches to form. Terminal sections of the stem cutting will provide a scion with terminal buds which can be advantageous with some plants. However, a scion from the terminal section of a stem cutting is smaller, and may require smaller rootstocks or lack the heavy push of new growth the larger scion provides. The smaller rootstock and reduced flush may result in less vigor in the subsequent graft. Choosing the best scion for the graft requires experience and an understanding of how the new plant will continue to grow in the nursery in the season(s) to follow.

Once the graft is completed and secured with a budding rubber or similar tying material, it is important to prevent the scion from drying out as the graft union heals. In dormant, winter grafts, the union is typically coated with a sealant. Doc Farwell's and Clark's Tree Kote are often used. Summer grafts are placed under mist systems or tented in a high humidity environment. Winter grafts will heal in 3 to 4 weeks, give or take, and summer grafts more quickly in 1 to 2 weeks.

GRAFT AFTERCARE

Initially, the objectives in graft aftercare are to reduce stress and provide the best environment possible. This means controlling heat, humidity, and any pests that may appear. Cooler environments will slow the graft healing process, while grafts will callous more quickly in warmer environments. Summer grafts will heal quickly, but care must be taken not to keep them too moist once the graft has healed. Excessive moisture is detrimental to grafts just as it can be to other crops in production. They should be weaned from the mist and acclimated back into the nursery environment as soon as the graft union has healed. Winter grafts don't necessarily benefit from additional heat to expedite healing, but it is usually advantageous to keep the graft above freezing at night. Daytime temperatures should not exceed

24 °C (75 °F). Too much heat can force the scion to break dormancy before the union has healed properly. In my nursery during the winter grafting season, I allow nighttime temperatures to drop to 3 °C (38 °F) in the propagation house, and the exhaust fans are set to vent the houses at 8 °C (65 °F).

Transition into nursery production is the secondary goal. The timing of this procedure depends on the weather, but generally the winter grafts remain in the propagation house until the threat of frost has passed. Since the grafts have been in a propagation house, they will have broken dormancy earlier than plants in cold frames; therefore late frosts can be a concern for many species. Once the threat of frost has passed and the first flush has hardened off a bit, grafts are shipped to my customers or potted into larger containers. They are moved outside into uncovered or shaded cold frames. Summer grafts are weaned from the mist, and then are placed outside in cold frames. They will then remain there until the following spring when they are either shipped to customers or potted up.

SUMMARY

Grafting is but one tool in the plant propagators toolbox. However, it can be an extremely useful one in certain situations. Some plants simply do not root in economical percentages, or have enough commercial value to justify tissue culture. Grafting may also serve a purpose when cutting material is available to the propagator out of season for rooting cuttings. For these reasons, grafting will remain a valuable option for plant propagation.

For the grafter to be successful, he or she must have a solid, proven recipe. This includes: (1) strong, vigorous rootstocks, (2) healthy scion material from healthy stock plants, (3) a sound grafting technique, and (4) diligent aftercare of the completed graft. With a complete understanding of these basics and plenty of practice, the grafter can enjoy the science and art of grafting.

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