

SWIMMING POOL
INSTALLATION AND
MAINTENANCE

TABLE OF CONTENTS

INTRODUCTION.....	4
1 THE TYPES OF POOLS	5
FIBERGLASS POOLS	6
CONCRETE POOLS	7
VINYL POOLS.....	8
ABOVE-GROUND POOLS.....	9
WHICH POOL IS RIGHT?.....	9
2 HOW POOLS WORK.....	10
DRAINS.....	10
SKIMMERS	11
PUMP SYSTEMS.....	11
FILTRATION SYSTEMS	12
RETURN VALVES	12
OTHER NEEDED FIXTURES	13
BELLS AND WHISTLES	14
3 WATER QUALITY.....	15
CHLORINE POOLS	15
SALINE POOLS.....	16
ALTERNATIVE WATER DISINFECTING METHODS	17
4 TIPS FOR INSTALLATION	19
TIP #1: DON'T INSTALL YOUR POOL YOURSELF.....	19
5 REGULAR MAINTENANCE	21
FILTER MAINTENANCE AND BACKWASHING	21
WATER QUALITY	23
SUMMARY: REGULAR MAINTENANCE SCHEDULE.....	26
6 SPA MAINTENANCE	27
7 WINTERIZING AND WEATHER	29
8 LONG-TERM MAINTENANCE: THE HORROR STORIES.....	31
"POPPING OUT"	31
VINYL TEARS	32

IT'S NOT ALL THAT HORRIFYING..... 32

INTRODUCTION

A swimming pool is one of the classic signs of the easy life. From the theme song of the Beverly Hillbillies to the closing scene of F. Scott Fitzgerald's "The Great Gatsby", swimming pools are associated with the rich, the leisurely, and the easy-going in life.

Which is why it's terrible when we learn, after we've spent a great deal of money and time selecting and installing a swimming pool, that that's no easy way to get an easy life. Maintaining a swimming pool can be a massive amount of work, one that makes even the best of us sometimes throw up our hands and say "What was I even thinking, digging this hole in my backyard and filling it up with expensive water?"

In this book, we'll talk about swimming pools. We'll talk about the different kinds of swimming pools available and how each is installed. We'll talk about the maintenance issues associated with each and what we need to do about different pools in different climates. And we'll talk about a few horror stories--not to frighten you so much as to make you aware that when the worst happens, you still have options--even if they are expensive.

As the modern poets say: the simple life is not so simple. The easy life isn't always easy. But with a firm grasp on some of these principles of year-round pool maintenance, you'll find it much easier than you otherwise would--and you'll have that much more time to enjoy the fruits of all your long efforts and labors.

1

THE TYPES OF POOLS

In talking about the different types of pools, it's important to remember three common-sense qualities that all pools have in common.

- All pools are gigantic holes in the ground.
- All pools are filled with water.
- The water in all pools needs to be filtered or purified in some way to make it safe for personal use.

There are some exceptions to these rules, in particular the first--there are temporary inflatable pools, for example, or above-ground "tank" style pools--but these tend not to have the same maintenance issues as classical swimming pools, nor are they as difficult to maintain, nor are they usually as satisfying. We'll cover some specific issues about above-ground pools at the end of this chapter, for those who opt for that often-simpler solution.

But for the most part, there's one crucial distinction between the different types of swimming pools available to the consumer: the type of lining used.

All pools more complicated than an "ol' swimming hole" need to be lined. To understand why, think about how much space in your home insurance policy is devoted to the topic of "water damage." Water is an inherently destructive force. It naturally erodes any container into which it's placed and it weakens stone moldings and the bonds between different construction elements. Generally speaking, it shortens the lifespan of any construction project by at least half. Your pool is no exception.

The key to pool maintenance is to think of your pool as a sustained battle between water and container. If you think of your pool in this way, you'll naturally think of the container's attributes designed to defend against water damage and to preserve its structure over time, and you'll understand intuitively what you need to do in order to keep your pool working safely and consistently over the years.

The fundamental choice that determines how easy or how difficult it'll be to maintain your pool is the choice of lining material used to make up the "container."

FIBERGLASS POOLS

Fiberglass pools are simply molded housings set into a pool excavation, otherwise known as "the giant hole in your backyard." Sand is applied to the concrete housing in order to allow the fiberglass mold to settle and shift while remaining fairly closely packed to the actual earth. Once you've chosen a fiberglass mold style, there's no possibility of shifting or revising it; you're stuck with what you've got.

Fiberglass is one of the most popular materials for a number of reasons. For one, it's very easy to mold into a variety of shapes. There are factories that do nothing but dream up different pool shapes and mold fiberglass pools to fit them. On the "minus side", all of this factory design work carries with it a certain overhead, and fiberglass pools can be more difficult to install for this reason.

The difficulty of designing fiberglass pools also means that although you have a great number of options for how your pool will be shapes and how it will behave, you don't have any freedom to customize within those options. If none of the factory standard fiberglass pools appeal to you, you don't have any way to design and build a fiberglass pool that you do like (without spending a great deal of money to retain a factory and a dedicated team of pool engineers of your own, that is.)

Fiberglass also has the advantage of being flexible. That doesn't sound like a huge advantage in pool design, but remember what we said about our basic principle: pool maintenance is about managing the war between the water and its container.

Fundamentally, all pools are holes in the ground--and the ground can and will shift over time. The added flexibility of fiberglass pools means that the pool body is more resistant to cracks and warping caused by changes in the earth surrounding the pool. On the minus side, if your fiberglass pool does crack, it can be very difficult to repair the crack in a way that won't cause you additional headaches down the years.

There are other advantages to fiberglass pools, in particular safety advantages. Fiberglass pool surfaces are smooth, making it more difficult for kids or other swimmers to get scraped or injured by brushing against rough concrete. It's also easy to install fiberglass pools, especially when compared to the undertaking that is putting a concrete pool in your backyard--a process that can involve weeks of waiting for concrete to dry and a seriously low margin for error if anything goes awry during the construction process.

CONCRETE POOLS

Concrete pools are the most classic swimming pool option, but bring with them a host of serious disadvantages.

Once you have your hole in the ground, the process of building a concrete pool starts with the steel framework. Crossbars of rebar steel are inserted into the ground to provide the pool with a "cage" of support that's resistant to earth movements.

After this, gunite or other sprayable concrete mixtures are applied to the steel framework, allowed to dry, and then recoated in order to smooth the eventual pool as much as possible. Different finishes can then be applied to the pool, depending on price. Tiles, paint, plaster, and pebbles are the most popular finishes, but different options are also available once the basic concrete is put in.

One major advantage of concrete pools is their customizability. As we've said, the number of different fiberglass pools available to you is limited by the pre-fabricated options on the market. The number of different concrete pools available to you is limited by nothing other than your budget, your imagination, and the technical competence of the contractors you choose to install your pool--in other words, you have more choice in how your pool will look and behave.

Another major advantage of concrete pools is their resistance to hot temperatures. Fiberglass pools are good at stretching to resist changes in the earth itself, but can be damaged by extreme, prolonged heat of the type most often found in southern or equatorial regions--in other words, the kind of climate where you'd most often want a swimming pool to begin with. Concrete pools can expand to some extent in order to resist the heat, giving your pool a longer lifetime in extreme temperatures.

However, you have a bit more to worry about when it comes to changes in the soil itself. This is the major disadvantage of concrete pools: the difficulty of doing anything if worst comes to worst and your pool does crack or break under the strain of above-average movement in the earth. Most of the time, concrete pools are a good, safe, flexible option. But in some extreme situations they're not as good at holding up to natural stresses as fiberglass.

As far as other disadvantages go, there's construction time to consider. Concrete pools take substantially longer to install and longer still to become usable--expect a minimum of about three weeks. This ultimately leaves you with a more stable and customizable pool, but requires substantially more planning in order to take advantage of a pool before a hot summer begins, and also causes more damage to your yard and landscaping while the pool is lying there half-finished. If you have small children or pets, you'll also have to be very careful to keep them out of

the pool area while it's under construction. This can turn into a nuisance very quickly.

VINYL POOLS

Vinyl pools are one of the cheapest and simplest options for in-ground pool installation. Vinyl pools start like any other pool: a massive hole in your backyard. The excavation is packed with sand and the walls of the pool are created by placing pre-fabricated "panels" into the earth.

The vinyl liner is placed in on top of this and attached to the top of the pool walls, sealing the places where the panels join (obvious weak points in the war between water and container.) The contractor will cut holes to allow for the placement of skimmers, drains, and other plumbing/drainage features, and then the space between the vinyl lining and the pool walls is stuffed with "backfill" in order to ensure that the lining won't shift too much.

Vinyl have the distinct advantage of being very good for cold-weather climates, since they make it very easy to winterize your pool by simply draining the water. Concrete and fiberglass pools are designed to hold water constantly, and they can suffer some major problems if allowed to drain for too long. As we'll see in our chapter on winterizing, a lot of extra work is needed to allow these pools to remain full over the cold months without letting the water freeze and damage the plumbing. Vinyl pools avoid these problems by simply letting you drain the whole thing easily for the winter.

But despite their basic simplicity, vinyl pools bring with them a host of maintenance issues. The vinyl covering is very sensitive to scratches, holes, and other such damage, which requires you to place some extra safety guidelines on kids or pets who use the pool, and eliminates certain kinds of sharp metal toys from use in a vinyl pool altogether. The vinyl covering will also need to be replaced from time to time due to age and wear.

If you're lucky, this will happen only once or twice over a multi-decade pool lifetime; if you're unlucky you can expect to shell this out every year or two. The need to replace the vinyl lining of a pool adds an ongoing construction expense (to the tune of a few thousand dollars) and some measure of headache to the whole situation. A failure to do this leads to serious leaks which can damage the underlying rock/soil behind the vinyl lining. If the leaks are serious enough it can actually cause damage to your entire house foundation.

ABOVE-GROUND POOLS

Above-ground pools carry with them a host of problems, but have one overpowering advantage: you don't need to excavate your yard in order to install one. Above-ground pools can usually be installed by using a pre-fab kit, assembled in a backyard, and allowed to stand for several months without significant maintenance issues. Above-ground pools are also portable, which is in and of itself a reason to choose them if you don't own your own home or don't have a stable career which allows you to remain in one place for the foreseeable future.

Above-ground pools do require two significant pieces of maintenance. For one, you need to have a level yard. In many suburban areas, this won't be a problem since the land is already fairly level. If your yard geography is a little bit more unorthodox, however, you're going to need to get your yard leveled in order to install an above-ground pool, which can be a considerable expense.

The other significant piece of maintenance is essentially the same as any pool would require: weekly chemical treatments performed to ensure water quality, appropriate cleaning and scrubbing, and careful vigilance.

Think of above-ground pools as "training pools": they'll get you in the habit of caring for a pool on a regular basis without requiring you to make costly land modifications or without requiring you to dive into the murky waters of foundation maintenance and drainage optimization. Just build, install, swim, and enjoy.

WHICH POOL IS RIGHT?

In general, here's a good rubric for making your decision:

- If safety is your primary concern, OR if you live in an area known for weak soil or tectonic activity, go with fiberglass.
- If customizability is your primary concern, OR if you live in an area known for extreme summertime heat, go with concrete.
- If cost is your primary concern, OR if you live in an area with continually low/freezing temperatures, go with vinyl.
- If you've never owned a pool before, you're planning to move soon, or you simply don't want to make a major financial commitment or house modification, go with above-ground--but keep your options open for the future.

2

HOW POOLS WORK

As we said before, pools are essentially gigantic holes in the ground, filled with water. But we were being somewhat disingenuous in saying this, because the water in your pool is doing much more than just sitting around waiting for swimmers to enjoy it. In reality, the water in a swimming pool is constantly active, flowing into and out of the pool through a complex system of pipes and filters. A good understanding of exactly how the water in your pool works is essential to understanding why certain maintenance steps are essential to the health and lifetime of your pool.

DRAINS

A pool without a drain is going to turn unsafe (and frankly disgusting) very quickly. Typically, a swimming pool has one or two main drains in addition to the other more specialized drains we'll be talking about just below.

The main drains in a pool need to be placed at the lowest point in the pool basin. Their job is to get rid of all the heavy debris that collects in a pool -and you'd better believe that there will be plenty of heavy debris that collects in a pool. The debris exits the pool through the main drains and passes through the pipe systems to the pool filter.

So you may have asked yourself: why two drains? The reason to install two main drains rather than just one is to avoid serious safety issues. As anyone with a bathtub knows, water tends to form a vortex when it drains quickly from a basin through a small opening. In a typical swimming pool, the amount of water being channeled through a drain is so high that the vortex created can actually trap a child against the bottom of the pool, rendering them unable to escape and quickly drowning them. This is obviously not the intended use for a pool drain. So a second drain is usually installed (along with all of the other types of drains in a typical swimming pool) in order to reduce the total amount of water that needs to drain from a single opening in the pool basin. Drains should also be outfitted with "antivortex coverings", which help to regulate pool drainage and prevent dangerous vortexes from forming.

SKIMMERS

Main drains help to clear all of the heavy debris from a pool. Skimmer drains help to clear all of the light debris that floats on the surface of a pool. This may seem like a minor or simply cosmetic problem, but even over the space of one day a serious amount of debris can form on the surface of the water in your pool, from fallen leaves to summer insects to worse. The skimmer drain allows water to sluice cleanly from the top of the pool through the skimmer basket, filtering out large amounts of debris before it can enter the filtration system.

Skimmer drains are usually equipped with a "floating weir", which is a type of door that swings open and shut depending on the amount of water pressing against it. When operating correctly, the floating weir will swing open and admit only as much water as the drainage system can handle into the pool's pipes.

Skimmer drains also have a secondary access pipe in addition to the drain leading to the filtration system. This is called the "equalizer line", and it connects to the main basin of the pool somewhere below the water line. If the water level in the pool drops below the level of the floating weir due to extra heat, regular maintenance, or for any other cause, this allows the pool to continue to draw only water through the skimmer basket line and avoids any air being pulled into the filtration system (which causes obvious problems.) The equalizer line needs to be outfitted with an antivortex covering, just like the main drains.

PUMP SYSTEMS

The water doesn't travel through the drain by gravity and water pressure alone. In order to make the pool run efficiently, an electrical pump system needs to be used.

The pump system is simply a small pump casing connected to the various drains and pipes that service the pool. It's usually kept out of sight from the rest of the pool, in part because it's not really appealing to look at (similar to the reason human internal organs are kept inside the body, not outside) and in part because keeping the pump out of sight also keeps it safe (ditto with human internal organs.)

Pumps need to be outfitted with strainer baskets that catch incoming debris before it reaches the actual filters. A good skimmer basket and drain covers will go a long way toward catching debris before it can cause you any trouble, but a strainer basket is necessary as a "last line of defense." Part of swimming pool maintenance involves emptying and cleaning the strainer basket regularly.

FILTRATION SYSTEMS

When the water leaves the pool through the drains, it needs to pass through a filtration system. This purifies the water by pulling out debris and allows clean water to return to the pool, keeping the pH balance stable and keeping the water from getting cloudy.

The filter system in a pool is fairly large and is usually kept above ground for easy access and maintenance. It looks something like a gigantic metal urn connected to various pipes.

There are several different types of filters. One of the simplest is a sand filter. When dirty water comes into the filtration system from the drains, pressure forces the water to travel down through the sand. The sand traps dirt and debris and leaves the exiting water clean.

Bear in mind the following caveat: even though it's called a sand filter, you can't simply pour any old sand into the filter and hope for the best. Only use specialized sand bought from a trusted pool supply store or other supplier. This sand will have a special square-crystal shape, designed for use in pool filtration. This should go without saying, but as you know, installing a pool is a major financial investment--better to be safe than sorry.

The two other major types of filters are diatomaceous earth filters and cartridge filters. Diatomaceous earth filters contain special grids lined with "diatomaceous earth", which are essentially the tiny skeletons of sea creatures known as "diatoms" mixed with regular sand. Diatomaceous earth is slightly more expensive, but filters pools more effectively and can be easier to maintain. Cartridge filters are exactly what they sound like: long plastic casings lined with cloth or other straining materials. Cartridge filters do a better job of cleaning debris from pool water, but will require regular replacement in addition to "backwashing" maintenance (which we'll cover shortly.)

RETURN VALVES

Once water leaves the filter, it can go to one of two places. One is the city sewer system. The other is the pool. The return valve is the connection from the bottom of the filter tank (where clean water collects) to the pool itself.

Return valves also generate a great deal of suction during use, and should be covered by antivortex coverings if possible. Ideally your pool will have

more than one return valve to minimize any problems caused by vortex formation. Return valves are the tiny "jets" that come out of the side of the pool, and any kids using the pool should be warned not to block the water flowing in through the "jets" in order to avoid any problems with creating extra suction in the filtration system. (Again, this seems like common sense, but for some reason kids naturally love to block off the return valves in a pool--if we all knew why kids take such pleasure in this, we'd no doubt be a lot happier in our adulthood than we are.)

OTHER NEEDED FIXTURES

There are two other fixtures that you'll want to have in your pool. Although these aren't as essential to making your pool work, they're still nice things to have and save you a lot of work in regular maintenance.

One is a connection to refill the pool with fresh water from the city water supply. You can in theory refill a pool with any source of fresh water (garden hoses, bearing jars one by one from a local well), but having a direct connection to the water supply in the pool itself saves you plenty of work when you'll inevitably need to replenish some of the water supply in your pool. This can happen due to simple use (water splashing onto the pool deck, water carried out on the body when exiting the pool, pool water used to fill a squirt gun or other toy) or due to underlying conditions (strong heat causing pool water to evaporate.) It's worth the time and extra expense to simply install this connection when you install the pool itself.

The other optional but vital fixture in a pool is the vacuum port. This is used to attach pool vacuum cleaners to the filtration system of the pool.

Hold on, you may be thinking. I already have all of these fancy drains to catch debris and dirt on the bottom of the water as well as on the surface. Why should I need to have a vacuum cleaner as well?

The answer is simply that as efficient as your main drains and skimmers are, they can't catch every little bit of dirt and debris. If you have a concrete pool in particular, lots of dirt will collect in the rough patches of concrete or plaster that line the pool basin. The drain could handle this dirt if the dirt ever made it to the drain, but it usually remains trapped along the side of the pool, where it makes the concrete look shabby and unappealing.

There are two options for cleaning it. One is to take a brush, dislodge all of the dirt, and hope for the best. The other is to use a vacuum cleaner which can stay in the pool all the time, snaking along the surface, slowly picking up dirt, and passing it through to the filter for disposal. It's slightly more expensive and you'll need to perform some regular

maintenance on the pool vacuum, but in the long run you'll be spending some money to save lots of time and effort: usually a good bargain.

One thing to watch out for when choosing a pool vacuum: pay attention to how the pool vacuum works. Some pool vacuums have their own on-board pumps and motors, while some work by drawing suction power from the pool's main pump system. There are advantages and disadvantages to both options.

Generally speaking, having an onboard pump for a pool vacuum is probably the better idea, since it puts less overall stress on your pool and ensures that if there's a problem with your pump system, you can at least keep the pool somewhat clean while the problem is being fixed.

Having an onboard pump involves some extra maintenance on your part, however, and probably some ongoing costs in terms of keeping the vacuum motor/pump assembly powered and operating. As long as you have some kind of vacuum, though, you'll be saving yourself immeasurably more work in terms of general maintenance than you'll be spending on the vacuum assembly itself.

BELLS AND WHISTLES

These are in no way essential, but there are extra options to make your pool experience more enjoyable that you might to think about when choosing and installing your pool. These can include slides, spas, bench seating, step or ladder exits, and diving boards.

Generally these options don't involve much in the way of additional maintenance (except, of course, for spas, which we'll talk about in a later chapter.) When choosing bells and whistles for your pool, the most prudent thing to think about is safety. Some kind of pool exit is a must to prevent people from injuring themselves by slipping when they're climbing out of a pool along the side.

Ladders are a cheap option, but bench seatings or molded steps are usually safer and more visually attractive. Any extra molding you put into your pool basin will give dirt and debris more of a chance to collect, however, and will cost you more in terms of overall maintenance time. Usually the extra enjoyment you'll get out of the pool will offset this extra maintenance, but it's still a good idea to be aware of these things before the gigantic hole is dug in your backyard (as I'm sure you'd agree.

Essentially, that's all there is to the functioning parts of a pool. There's just one big issue in keeping your pool working that we need to cover before moving on to actual maintenance issues: the major issue of water quality.

3

WATER QUALITY

Water quality doesn't just refer to making your pool look pretty, all sparkling and blue in the summer sunlight. It also refers to making sure that your pool is safe from disease, as well as free of unsightly and deadly algae.

It's a given that a pool needs to be disinfected. Water is, after all, the source of life--and that isn't restricted to human life. All animals love water, including insects and algae--and germs love water too. Your swimming pool without regular disinfections is essentially a breeding ground for disease.

The problem, of course, is one of degree. Disinfectants are poisons, after all, designed to kill unwanted life. You probably don't define "unwanted life" as including "the friends and family members who use your pool." So the key to maintaining your water quality is to keep the water filled with enough disinfectant to kill any unwanted organisms who use your pool as a convenient spawning ground, but not so much disinfectant that your pool becomes unsafe.

We can think of a pool as a sustained war between earth and water, as we said. Think of your pool water as a sustained war between safe water and clean water.

CHLORINE POOLS

Chlorine is the oldest method of sanitizing public pools, and still one of the best. If you're a first-time pool owner or if you just want to "get your feet wet" with pool maintenance, chlorine is most likely what you'll want to use.

The special chemical properties of chlorine make it ideal for use in swimming pools--as opposed to, say, muriatic acid or some other more frightening option. Not that chlorine in and of itself isn't frightening--chlorine gas has long been a weapon used in modern warfare--but when mixed with water, chlorine has a history of doing the job you want it to do without "working overtime."

When chlorine tablets are added to pool water, two compounds are created: "free chlorine" and "combined chlorine." Do the names sound

too similar? Think of them this way: free chlorine is "good chlorine." Combined is "bad."

Why is free chlorine good and combined chlorine bad? Simply: free chlorine is able to move freely around the pool, attacking and killing microorganisms. Combined chlorine doesn't work effectively to kill microorganisms. It just stays in the pool, floating around, producing unpleasant "pool smells" and bleaching people's hair and bathing suits. Left unchecked, it can even eat away at the walls of a pool and cause maintenance nightmares.

You've probably seen or been in a pool with too much combined chlorine before. The usual complaint from people is something like: "There's too much chlorine in this pool! I can smell it!" Surprisingly, the reason the pool smells like chlorine isn't because there's too much chlorine in the pool: there's actually too little, or at least too little that's doing the job it's supposed to do.

So the key to a good, workable pool is to keep the chlorine balance in your pool at the proper level. We'll talk a little more about this later when we talk about the regular maintenance your pool needs.

SALINE POOLS

Saline pools are the most recent development in pool sanitizing systems. Because they're so recent and because they're presented as an ideal alternative to traditional chlorine pools, you might be tempted to think that saline pools are some kind of radically different approach to pool maintenance.

But if you remember your high school chemistry, you'll remember that salt, chemically, is just sodium chloride: NaCl. In other words, there's chlorine in it! And that's all a saline pool is, essentially: an alternative method of delivering chlorine to your pool.

How does it work? Simple. The water is filled with salt to an acceptable level, usually around 3000 ppm (parts per million), although the exact amount depends on the pool's specific construction. Two components are added into the pool's filtration system just after clean water passes through the filter: a control box and a "salt cell."

The control box is what you use to regulate the amount of chlorine fed into your pool. By changing the time over which the salt cell is charged with electricity, you can change the rate of chlorine production and delivery. There's no set formula for ideal chlorine production: either follow your pool installer's recommendations, or--if you've decided to install your pool yourself--maintain a chlorine level that keeps the water at an ideal pH balance.

When the control box is charging the salt cell, the salt cell converts the salt in the water into natural chlorine. It does this through an electrolytic process. The salt cell is filled with metal plates which carry alternating positive and negative charges. When the cell is active, the water is electrified, which forces the salt in it to break down chemically into sodium deposits and natural chlorine. The chlorine then flows back into the water through the returns.

You don't need to really know anything about how that chemical reaction works in order to maintain a saline pool: just know that salt water goes in, chlorinated water comes out. But you've probably already spotted one maintenance issue with saline pools from that decision: where do the sodium deposits go? The answer: more often than not, they adhere to the plates in the salt cell. So every so often you'll need to take out your salt cell and clean the plates of any deposits. Ideally, you can find a salt cell with a self-cleaning feature, which allows you to reverse the polarity on the water in order to shake the sodium deposits from the plates. Again: there's no reason to know the chemistry behind it; just know that it needs to happen.

ALTERNATIVE WATER DISINFECTING METHODS

It's hard to beat chlorine, whatever the delivery method, when it comes to disinfecting and sanitizing a pool. But in the words of Mr. Spock, there are always alternatives.

The most popular alternative disinfecting agent for a pool is bromine. Bromine occupies the same chemical "niche" as chlorine and works in almost exactly the same way to clean a pool. Due to its comparative rarity, however, (after all, you can get chlorine from salt!), bromine carries with it a much higher price tag and is sometimes hard to find in smaller towns.

Despite the cost, bromine is actually preferred by some pool owners, and may be an option worth exploring if you have a non-saline pool. The reason has to do with the chemistry of the water and how your disinfecting agents interact with it.

When you add chlorine to your pool, part of the chlorine breaks off to kill bacteria and other agents. Once the good chlorine kills bacteria, it essentially vanishes and ceases to be effective. The rest of the chlorine sits around, irritating people's skin and eyes and smelling up the pool until it's taken care of. When bromine is added to the pool, all of the bromine is used in killing bacteria, since bromine is slightly more stable as a chemical than chlorine and isn't as likely to combine with other chemicals in your pool's water to cause unwanted compounds. Once the filtration

system removes all of the dead bacteria from the pool, the bromine is still active in the water and can be used to kill more bacteria.

In other words: bromine stays active in the water for longer. Despite the higher price, a smaller amount of bromine can be used to do the same work as chlorine. That's the great virtue of bromine--and also the great vice.

Since bromine and chlorine are so similar chemically, the human body often treats them in the same way when performing its own natural maintenance. This means that if you're naturally allergic to chlorine, you'll usually be equally as allergic to bromine. But since bromine is so stable compared to chlorine, it's very difficult to get bromine off of your body and clothes by washing them or taking a shower: the bromine tends to linger. Since bromine doesn't smell or cause as much damage to the body as chlorine, many people don't find this to be a problem, but if you're physically sensitive to chlorine already, bromine is not a good alternative. If you just don't like the smell of chlorine--and you don't mind the cost and availability issues--bromine may be your answer.

4

TIPS FOR INSTALLATION

TIP #1: DON'T INSTALL YOUR POOL YOURSELF

That's not a joke. Some parts of installing a pool are very simple: digging out the backyard, installing rebar steel or other pool frameworks, cutting holes for drains in vinyl pool liners, even spraying gunite or other concrete mixes. For the most part, this is just a matter of some calculation and construction know-how, and there's no reason you can't simply do this portion of the work yourself.

What you don't want to do yourself unless you're very, very clear on what you're doing is to install the filtration system, pumps, and drains. Pools, for all their basic simplicity (water flows out the drains, passes through the filter, back in through the returns, rinse, repeat), are actually quite sophisticated when it comes to the minutiae of water pressure, managing drain loads, and other similar issues. A single miscalculation can lead to serious safety issues when it comes to drain suction, water buildup, or stress and strain on your pump motor. At the very least, it'll lead to a significantly shorter lifespan for your pool. And a major problem with miscalculations in your pool setup is the fact that unless you're willing to dig up your entire yard again and spend tons of money draining and refilling your pool, it's impossible to fix errors in your pool's construction.

If you must install your pool yourself, at least follow these steps:

- Speak to a contractor who's had some experience with pool installation. Ask if he or she would be willing to evaluate your yard and existing plumbing in order to point out any serious potential problems during excavation and installation. This will cost you some money, but will save you plenty of headaches--imagine how horrible it would be, for example, to be merrily digging out your backyard when you strike a trunk cable line or water main.
- Secure all the materials you'll need well before you start. The only exception to this should be pool chemicals, since these can "go bad" easily if improperly stored, wasting your money, and you won't really be able to use them in your pool until sometime after construction is complete and the pool is filled (since they can cause damage to fresh construction.)

- Secure any help you'll have for the installation project well in advance. If you're hiring laborers to help you, or just asking friends or relatives for some support, make sure you have a good schedule for your most demanding tasks (installing the pool basin if you're working with a fiberglass pool, or spraying and smoothing gunite if you're working with a concrete pool) and make sure they'll be available to help out.
- Set up a good timetable for installation and stick to it. The longer a pool remains unfilled and incomplete, the more chances there are for problems. Filling a pool adds so much weight to it that it helps it to remain anchored in place, and if you're not careful to move quickly from installing the basin to filling the pool with water you can easily face a situation where your basin "pops out" of the ground, cracks, or other horror stories. If you're only able to work on your pool on weekends, be sure to set up your schedule so you can make the most out of necessary drying times, settling times, or other planned time gaps. Expect to spend at least two to three weeks installing your pool, more if you're doing a particularly complex installation (e.g. concrete, spas, or advanced molding.)
- Seriously, don't do this yourself! Find a reputable contractor with whom you're comfortable working and make sure to supervise them closely using the knowledge you have from this book about how pools work. You'll save yourself an infinite amount of hassle, you'll avoid lots of future problems, and you'll understand how your pool is put together so you'll be better able to maintain it.

5

REGULAR MAINTENANCE

So at this point we've covered all of the components of a pool. We know about the advantages and disadvantages of each basin type, about all of the parts that fit together to make a pool work, and about how disinfectants ensure both water quality and personal safety for the people using the pool. In other words: we've done all of the hard work.

Now it's time to use all of that information to talk about exactly how one goes about maintaining a pool for regular use. Once you understand how the parts of a pool fit together, this is simple. Just keep the way a pool works in the back of your mind--and make sure that you take care of any problems that stand in the way of the pool's working.

Need more specifics? Press on.

FILTER MAINTENANCE AND BACKWASHING

One of the most critical components of the pool, as we've discussed, is the filtration system. It does all of the hard work of keeping the pool water free of debris, safe for use, and pleasant to look at. In the process of doing all of this hard work, it's naturally exposed to all of the worst things a pool has to offer in terms of dirt, oil, and other accumulations of gunk. So the filter is one of the most critical pieces of equipment to keep working.

How often should you run your pool filter? The answer depends on the size of the pool and the climate outside. Generally speaking, you'll want to run your pool about six hours a day during less hot months, probably from the time you start using the pool up to about Memorial Day. When the weather is hotter and the pool gets used more often, it's more important to maintain water quality in order to avoid damage from the climate and from dirt and grit in the water. After Memorial Day until roughly Labor Day, it's a good idea to run your pool filter for at least twelve or so hours every day. At the very least, make sure your pool motor is running whenever people are actually using the pool. If you follow these guidelines, you'll keep your water looking nice and clean in 99% of situations.

So what about that other 1%, when your water starts turning green and cloudy and regular filter use doesn't seem to be doing anything to fix it?

There are three options. One: run your filter more. Two: backwash the filtration system. Three: "brute force" the water clarity by using bleach or other disinfecting agents. Try these options in this order.

Running your filter more is often a reasonable way to solve persistent clarity problems. Simply run your filter constantly, 24/7, until your water clarity gets back to normal. The only real limit on this strategy is the amount of money you have in your utilities budget--since you'll be spending a lot of extra electricity to keep your motor running this often--and the patience of your neighbors, since your pool pump's motor will be making much more noise than normal during nighttime hours.

If this fails, you can resort to the second option: performing "backwashing" maintenance on your pool.

What is "backwashing" maintenance? Answer: along with maintaining water quality, backwashing is the single most important thing you can do to ensure the health of your pool.

Eventually, so much debris passes through the sand filter that it becomes clogged and it slows down significantly in filtering and cleaning the water. Backwashing cleans the filters so that they can again work efficiently in keeping the water free of debris.

To backwash a pool, the owner closes off the valves that transmit the clean water to the pool returns, as well as the valve that brings dirty water in through the drains. Another valve is opened: one that transmits wastewater to the city sewer system. The pool pump is used to flush water backward through the filter. This forces all the collected debris out of the sand, diatomaceous earth, or cartridge filter and washes it away into the city sewer system: no fuss, no muss. Once the filter is cleaned, the valves can be returned to their normal configuration and the pool filter can work normally.

We're introducing the topic of backwashing as a method for cleaning pools that seem clogged beyond the filter and pump's ordinary ability to remedy. But backwashing can and should be part of your ordinary maintenance routine as well. Generally speaking, you should backwash your pool roughly every two times you add chlorine, or at least every two weeks. It's slightly more of a hassle, but it can help prolong the life of your filter and saves you some scrubbing and vacuuming work in the bargain.

The third option for clearing your pool of dirt and debris when other methods don't seem to work is the "brute force" approach. Add one or two gallons of bleach to the pool water and hope for the best. This is an unorthodox method for cleaning a pool, but it does actually work to break down difficult-to-eradicate debris and dirt and help the filter work more efficiently.

If all of the above fails, take a water sample to your local pool supply store. The problem in this case probably has more to do with your water

quality than with anything in the pump and filtration system, and you'll want a specialist in pool water quality problems to diagnose your problem and give you a solution for it, probably of the chemical variety.

As far as other issues with dirt and debris go: as we've said, your filtration system isn't perfect. That's why there are a few extra lines of defense against debris and clogs. Part of your regular pool maintenance should be to clear skimmer baskets regularly, no less than once a week. If your pool is extra prone to clogs or surface debris--for example, if a backyard or neighboring tree produces a great deal of leaf debris, or if you have a summertime infestation of Junebugs--you'll need to clear them every two days, or as often as it takes to keep your skimmers working properly. The strainer basket in the filtration system can be cleaned more sporadically, with once a month being probably sufficient for most problems.

Brushing down the sides of the pool is less vital for your pool's function, but is important as far as cosmetic appearance goes. Brushing down the pool keeps the sides looking clean and normal, as well as preventing occasional stains or other more permanent damage. Generally you should brush down your pool an hour after use in order to get rid of dirt, dead skin, and other heavy debris. Waiting an hour before you brush down the pool allows the dirt to settle and keeps you from having to brush the pool twice. If the pool goes unused for a while, it's a good idea to brush the pool down every week.

And as we said before, a pool vacuum cleaner isn't vital for your pool's continued functioning--but it's certainly nice to have. If you're using a pool vacuum cleaner, you can reduce the amount of time you spend brushing the pool walls to about once a week, since the vacuum cleaner will take care of most of the excess dirt created through daily use. The brush will just let you dislodge dirt from hard-to-reach areas that the vacuum cleaner can't easily access.

WATER QUALITY

Maintaining the water quality of your pool, as we've said, is one of the most complicated yet necessary tasks of regular pool maintenance. There are four basic steps to simplify this complex task and ensure that you can use your pool regularly and safely.

The first guideline: make sure you chlorinate your pool regularly. If you're using a saline pool, this is just a matter of adjusting the levels on the control box in your filtration system. If you're using a traditional chlorine pool, you'll need to add chlorine by hand or install an auto-feeder system. The latter option works similarly to a saline pool's control box: it contains a large amount of chlorine tablets, and releases small doses into the water whenever water passes through the filter. You can adjust the auto-feeder to regulate the level of chlorine that passes into your pool. If

you don't do this, you'll need to just add chlorine tablets by hand in order to keep everything working normally.

Where should you add the chlorine, and what type of chlorine should you use? The first question is much easier to answer than the second: add the chlorine somewhere in the filtration process if possible. An auto-feeder will take care of this automatically, of course. If you don't have one, the best place to put chlorine is usually in the skimmer baskets. Since the skimmer baskets have a direct line to the filtration system, you can make sure that the chlorine flows into the filtered water easily and efficiently without bunching up in various parts of the pool. The floating weir also regulates the amount of water in the skimmer baskets and prevents much of it from floating back into the dirty pool water.

The type of chlorine you should use depends on how much you want to fine-tune your pool maintenance routine. In general, 3" chlorine tablets from a pool supply store will do the job. They dissolve more slowly than most other options, making sure that fresh chlorine is being fed to the pool on a regular basis. 1" tablets are also an option, but require you to add more chlorine to the pool regularly in order to keep the water clean and fresh. If you're really obsessive about chlorine levels, you can use powder chlorine. This lets you add exact dosages of chlorine to your water all at once, but requires you to calculate those dosages every day and pre-dissolve the chlorine in buckets before you add it to the filtration system (in order to prevent bunching or hard-to-get-rid-of mineral deposits.)

The level of chlorine you should be shooting for is as follows: 1 part per millionth of total chlorine, and 1.5 parts per millionth of free chlorine (or "good chlorine.") Usually one 3" tablet of chlorine a day is enough to maintain these levels in most standard-sized pools, but if you're worried about this you can buy a free chlorine testing kit in order to check the exact levels, or you can simply take a water sample to a local pool supply store for analysis.

As we said earlier, keeping the free chlorine level in your pool high is what keeps the pool free of diseases and other microorganisms, and what helps prevent unwanted odors or skin irritation. After chlorine has been in the pool for a while, however, it ceases to be effective, and all you're left with is the combined chlorine--bad chlorine--with the husks of dead bacteria clinging to it. In order to get rid of that bad chlorine and the smells and irritation it brings with it, you'll need to follow the second guideline for maintaining water quality: shock treatment.

This sounds more frightening than it is. The rule for shocking your pool is: once a week, add five to ten times the amount of chlorine you would usually add to your pool. You can do this by simply adding additional tablets, or you can do it by dumping powdered chlorine directly into the dirty pool water and running your filtration system. The new mega-dosage of chlorine will flood the pool with additional free chlorine and help to clear out the bad chlorine that lingers.

In addition to regularly shocking the pool, you should perform shock treatments in the following situations:

- If the pool is starting to show the first signs of algae buildup (green color to the water, green residue around the water line)
- After a heavy rainfall
- After a prolonged period of heavy bather usage (an all-day pool party with twenty kids, for example)
- Any time there's a persistent issue with heavy "chlorine smell"
- Any time someone willingly or unwillingly urinates in the pool. Urine bonds with free chlorine to create bad chlorine more quickly than normal. Shocking the pool eliminates this problem (and you'll probably feel like doing it anyway if you find out someone has peed in the pool.)

There's no major danger in shocking your pool, even if it seems like mega-dosing your pool with hazardous chemicals is a bad idea. A good rule of thumb is to wait from fifteen minutes to an hour after shocking the pool to use it. If the pool seems to be clouding over after shocking, don't use it: the free chlorine isn't doing its job right and you may have a problem with your water's pH level. Get the water tested and fix the issue before you use the pool.

(One additional note: we mention megadoses of chlorine here as your major shock treatment option because it's convenient to use the chemicals that you already have on hand. There are plenty of other options for shock treatments, however, all of them available at a good pool supply store. If you're worried about megadosing your pool with chlorine for some reason, or if your water quality requires a lower amount of chlorine than normal to remain in the ideal range, you might want to explore some of these alternatives.)

The third major guideline for maintaining water quality: keep your pool water's pH balance between 7.2 and 7.8.

The pH balance is a measure of the pool's acidity. A high pH balance indicates a high measure of alkalinity; a zero pH balance indicates a high measure of acidity. A rating of 7 indicates an absolutely neutral balance between the two. You want your pool's water to be close to this, tending slightly more toward alkalinity than acidity. A lower pH causes damage to the metal fixtures in your pool's filtration system and pump, as well as the metal walls in a vinyl pool. A higher pH makes the pool cloudier and prevents chlorine from working effectively, forcing you to use more of it in order to keep the pool sanitized.

You can alter the pH balance of a pool by adding chemicals to it. Most frequently you'll need to raise the pH balance--make the pool more

alkaline--by adding baking soda or soda ash in large doses to the skimmer baskets. You can lower the pH balance--make the pool more acidic--by adding sodium bisulfate, or, yes, chlorine. How much of each you'll need to add in order to adjust the pH depends more than anything on the ground water in your area. It's a good idea to take a water sample to a pool supply store as soon as you've installed your pool and added your first regular dose of chlorine to get an idea of your "baseline" pH. You can then buy the chemicals you'll need in order to keep your pH within the proper range, and you can make adding those chemicals part of your weekly maintenance routine.

SUMMARY: REGULAR MAINTENANCE SCHEDULE

DAILY MAINTENANCE:

- Add chlorine to the pool.
- Run the filtration system from 6 to 12 hours, depending on the time of year.

WEEKLY MAINTENANCE:

- Brush down the pool sides.
- Shock the pool with megadoses of chlorine.
- Backwash the pool filter.
- Add any chemicals needed to maintain an ideal pH balance.
- Clean the skimmer baskets or any other obvious clogs.

6

SPA MAINTENANCE

Maintaining a spa is almost exactly the same as maintaining a pool. The same filtration systems, chlorination issues, and other issues apply. The major differences between a spa and a pool are the frequency with which you'll need to brush the walls and issues related to the heater.

Since a spa is invariably more enclosed than a pool, there are more tiny cracks into which dirt and debris can creep. You'll need to brush down the interior of a spa more frequently in order to release that dirt and debris. This is a common sense issue if you know about how pools work, but many people tend to forget it and wonder why their spa gets so much dirtier than their pool. If you give the spa a quick brushdown every day you'll avoid having to do more elaborate and tiresome cleanups once a week, and you'll keep your spa looking nicer for longer.

Since spas are almost always kept separate from the main body of the pool, there are issues related to the cleanness of the water's surface that you'll have to deal with. There aren't usually skimmer baskets in a spa, for example. Many people solve this problem by putting the water return for the filtration system in the spa and setting up a "spillway" leading from the spa to the pool. This lets the surface debris from the spa float into the pool where the pool vacuum, skimmer baskets, and better drainage systems can take care of it. If your spa is kept entirely separate from your pool, you'll need to skim the water with a net yourself at least once a day in order to keep the surface clear of obvious debris that could affect the filtration system.

The biggest issue with spa maintenance is of course the heater. This plugs into the pool's filtration system. When the spa is active, the heater is turned on and water that passes through the filter is directed into the heater. The heated water then passes into the spa, heating it up.

It's usually possible to heat a swimming pool as well, since the heater is part of the basic filtration system and it essentially doesn't matter where the returned water goes to. In practice, it's usually less common to find a heated pool than a heated spa, simply because it takes much more energy to heat a water volume that's anywhere from five to twenty times as great as the spa's. The cost of heating a pool makes it a nice option for an occasional fall pool party and a terrible option for everyday use.

Maintaining the heater is fairly simple, considering that it's essentially a massive outdoor heating coil. The big choice you have to make is whether to go with natural gas or electricity for your energy source. If

natural gas is available, it should be the immediate choice since it's substantially cheaper and more efficient at heating water. Electricity will take longer to heat the water and will likely cost you additional money in utilities. (There are also options for wood heating or solar panel heating, but they usually involve substantial installation requirements that are somewhat beyond the scope of this book. The basic logic of connecting everything to the spa itself is the same.)

If you do go with an electrical heater, use common sense: keep the heater a safe distance away from the rest of the pool. Usually a pool shed with other filtration pipes is a safe place, as long as everything else works as it should. Most spa heaters are designed to shield sensitive electric components from the water, but better to be safe than sorry.

7

WINTERIZING AND WEATHER

Despite what Brian Wilson and the Beach Boys may tell you, the summer is not endless and sometimes you'll have to close up your pool for the cold weather months.

If you live in a warmer climate with an extremely low frequency of below freezing temperatures, you don't need to be quite so aggressive when winterizing your pool. But in colder climates--anywhere with more than two weeks of days with below freezing weather, on average--you need to be aggressive indeed to make sure that your pool's entire underground pipe system is completely cleaned out of water. If water freezes underground during the winter, it'll crack your pipes, allowing water to leak into the earth surrounding your pool. If that happens, expect to pay plenty in repairs, and expect to have a useless hole in the ground while you wait for everything to be fixed.

The steps to winterizing your pool are as follows:

- Backwash your pool filter thoroughly. Drain out any filter tanks, disconnect any cartridge filters, and shop vac any filter connections in order to ensure that all of the water is gone.
- Disconnect your pool pump and filter. Make sure, again, that there's no water remaining in the pump.
- Loosen all pipe fittings in your filtration system to make sure that no water collects, expands, and cracks the pipes.
- Remove the skimmer baskets entirely and store them in a safe place.
- Hook up a shop vac to the pipe fittings in the filtration system (again, make sure that the pump and filter are out of the picture at this point, or face futility.) Blow out all of the water from the return pipe system first: when you see air bubbles start to form in the pool water, you'll know that the pipe is cleared out. Plug the water returns tightly on the side of the pool.
- Do the same for the skimmer baskets and the vacuum port. "Gizzmos" are fittings specially designed for winterizing skimmer baskets, and should be used to plug the skimmer basket drains.

- Blow all of the water out of the main drains. Since it's impossible to conveniently plug the main drains in the pool itself, quickly plug the main drain pipes in your filter area. This should create an air-tight seal which will prevent most water from breaking into the underground main drain pipes over the winter.
- Wait a minute, you've been saying through the last three points. I don't have a shop vac. Okay. It's not as good of an option since you're not getting rid of all of the underground water, but you can avoid having to blow out any pipes by simply draining water from your pool until the water is below the skimmer basket level. This can cause stress on your pool basin and leaves you vulnerable to some types of ice damage, so if you can blow the water out of your pipes, do it. But if you can't and you feel like taking risks, go for this option.
- Once all of the drains are closed up, add winterizing chemicals (available at a pool supply store) to the pool water. Make sure you add a shock treatment as well, since in order to keep the pool safe over the winter, you'll need to keep the chlorine content of the water extremely high (ideally around 3 ppm, or triple the normal level of combined chlorine.)
- Place a winter cover over the pool. If your pool cover has ripped during the summer, don't take chances: replace it!
- Keep an eye on your pool cover over the winter. If water collects on the top of it after a rainfall or for any other reason, make sure to clean the water out. The pool cover will start to corrode due to the standing water and can buckle at the edges, making it impossible to keep the water in the pool as warm as it needs to be over the cold winter months.

8

LONG-TERM MAINTENANCE: THE HORROR STORIES

If you follow the advice in this book, you'll be able to avoid most of the problems in this chapter. But here are some long-term maintenance issues that you should hope never to see, and what you can do about them.

"POPPING OUT"

As we touched on briefly in the first chapter, pools are subject to stress from the surrounding earth. To some extent, your pool basin resists this stress by floating on the existing groundwater within the backyard excavation. This is especially true with fiberglass pools, which are essentially nothing more than boat hulls with drains attached.

Ordinarily, the water in the pool weighs the pool basin down enough to counteract this buoyancy. But changes in the ground water, evaporation of the water in the pool, or the need to drain the pool for some extended cleaning (something you shouldn't do unless there's an extreme emergency) can lead to the pool basin actually popping out of the ground.

In this situation, you have two options:

- Refill the pool and hope for the best (not the ideal option)
- Bring in a contractor. He'll have to remove the pool basin and modify your existing pool excavation in order to fit the basin as well as it did when the pool was freshly-dug.

While your pool basin is removed, you can of course check it for any leaks, signs of other wear, or anything else that'll help take the sting of paying for major repairs out of the way.

You can avoid this problem and the nightmares associated with it first of all by following our advice in chapter 4 and not trying to install your pool yourself. It's also a good idea to keep the level of water in your pool high and to make sure you maintain the water's pH balance to avoid any

corrosion, which can lead to leaks and faster erosion of the earth surrounding your pool.

VINYL TEARS

It's not the title of a 1980s exploitation movie; it's a serious problem for vinyl pool owners. As we mentioned in our first chapter, vinyl pools are very vulnerable to damage from sharp toys, kids, or general wear and tear. It's important to check your vinyl pool coating at least once every year or two in order to make sure there aren't any tears, cracks, or anything else that can lead to leaks and damage to the surrounding ground water--or, equally horrifying, to the metal walls that surround your vinyl pool.

It's not a good idea to drain your pool more often than every few years for the reasons we talked about above: emptying your pool gives the earth a substantial advantage over the water and can change the shape and structural rigidity of your pool significantly. But emptying the pool to check for vinyl tears is actually a good idea in the long run if you're using a vinyl pool. Walk across the inside of the pool and inspect every surface carefully for any sign of tears.

Once you've done this, fill the pool up again slowly, a foot of water at a time. Leave the pool alone for an hour or so and see if the water level drops. (Don't wait longer than that or evaporation will drain off too much water for you to make a clear judgment.) If it doesn't, continue filling the pool. If you notice a significant drop in the water level after an hour, stop filling the pool and inspect the area closely for signs of air bubbles or other leaks. This is a good way to diagnose tears in your vinyl covering without wasting too much time.

If you do find tears, don't try to patch them. Spend the extra few thousand dollars to get the cover replaced. Otherwise, you'll risk having to drain your pool more frequently in order to diagnose and patch leaks--and remember, the more often your pool is empty, the more damage occurs to its underlying construction. You don't want to have to spend even more money to rebuild your entire pool; spend a little bit more up front and make sure it's done right.

IT'S NOT ALL THAT HORRIFYING

And again, remember: the situations in this chapter are horror stories, worst-case scenarios. If you follow the daily and weekly maintenance recommendations in this book religiously, if you make sure that your pool is built right from the ground up, and if you enjoy the pool responsibly

with an eye to water quality and avoiding leaks and damage, your pool will last you for years--and you'll have a piece of that easy life that's the reason, after all, that we all wanted swimming pools in the first place. Even if they are a pain in the neck.