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CHAPTER 1

THE STORY BEGINS

CAN YOU KEEP A FLY AS A PET? It's a strange question. An even stranger one might be: would you really want to?

But if your desire is firm and fly petting is your thing, then the answer to both questions is a strange and certain `yes'. Of course you can keep a fly as a pet. If you can catch it, that is.

Swatting is easy enough – more than 200 wing beats per second translate to a speed of only 7.5 kilometres per hour, about that of a brisk human walk. That said, trapping an unsuspecting housefly using an overturned tumbler or, if you're really good, two rapidly cupped hands, will most likely require many, mostly futile, attempts. If and when you do catch it, you'll need to bring your new pet to heel.

That's the thing about houseflies. They fly around a lot, which makes them difficult to train, or at the very least attach to a leash. But it can be done. Fly fundis, clearly as brutal as they are bored, will advise you to pop your fly into a plastic container and stick it in the fridge for a few minutes (or maybe it's the freezer; they can't quite agree). This will cool and calm it down to almost a standstill. Then you can take it out, dazed and confused but still very much alive, and tie piece of string or dental floss around its body. A long, human hair can work well, too. That's if the pet fly thing isn't strange enough for you already.

Finally, you tie the other end of the floss, hair or string to a heavy object like a spoon or paperweight. And there you have it: your very own pet fly, fit for hours of circling obediently around. It's a great way to spend a lazy Sunday afternoon. A YouTube video waiting to happen.

In the interest of good personal hygiene and insect welfare, you'd probably be ill-advised to try this at home. Plus a housefly would not make a good pet. On the contrary, it's built to be a bad one. Whether tied to a string or trapped in a cosy kitchen container, it won't last more than a couple of days in captivity. And, even if it does, at a centimetre in length and weighing only 12 or so milligrams, it's way too small to be scratched under the chin or stroked. A fly generally goes out of its way to avoid being touched by anything at all, even a gust of wind. And if it were more amenable to fun, games and affection, the bacteria it brings along would be even more of a problem.

> After investigating almost 400 000 houseflies, a pair of Chinese entomologists concluded that a single fly comes with more than 1.9 million bacteria attached.

After investigating almost 400,000 houseflies – an unenviable task to be sure – Doctors Yao Hong-Wei and Yuan De-cheng, Chinese entomologists from Zhejiang University, Hangzhou, concluded that a single fly comes with more than 1.9 million bacteria attached. That is some serious baggage. In fact, flies are thought to be responsible for more human deaths than humans are responsible for fly ones. Which, if you consider the booming bug spray and flytrap industries, is a lot (and a very good reason to avoid flies like the plague).

Clearly, a fly can be kept as a pet, but you probably don't want one after all. Why? Because pets are meant to improve your life in some way, and flies just don't. Mostly they spend their time turning up in soup, irritating Australians (who had to invent the cork-rimmed hat to deal with them), landing on all kinds of garbage and generally making life not better, but worse. It's no wonder they've never been domesticated. It's no wonder no one has ever even tried.

This is certainly not for a lack of time. Flies are thought to have been around on Earth for more than 20 million years – about 19.5 million more than any form of human life. Their ancestors probably pestered our ancestors. Our ancestors probably fashioned rudimentary flyswatters out of leaves. And it's been interspecies war ever since.

We try to kill them, they try to kill us, and despite countless casualties on either side, no one's really winning. In fact, it all seems rather futile. Especially if you consider the fact that we might be able to

combine our talents to do something good. Like saving the world, maybe. Because it does need saving, and it's all our fault.

Honey catches more flies than vinegar, so let me say this as sweetly as I can. If the Earth is a great big picnic blanket laid out for all living things, then the flies aren't the ones walking all over the potato salad with their dirty little feet. No. The humans are the real pests at this picnic called life. In addition to the way we pump out waste (something the flies might thank us for if no one else does), we also have a tendency to eat, drink and merrily use up natural resources like there's no tomorrow. Until tomorrow comes, of course. Which it always does in the end.

Consider the fish in the ocean. Because of our actions they're dropping like, well, flies. Actually it's because of our actions and our appetites – and not just our appetite for the fish themselves. It all comes down to protein. Humans really want and need protein. Technically we need it because it plays a structural and functional role in every cell, as well as in the membranes, enzymes and hormones that keep things running. Not so technically, we also like protein because it tastes good – particularly the kind that comes from animals.

A quick biology lesson: protein is made up of amino acid building blocks. Although the body can manufacture certain of these amino acids in-house, nine of them have to be provided by our diet. These are called the \`essential' or \`indispensible' amino acids, and their indispensability is what makes some proteins more valuable than others.

Animal proteins like meat, poultry, fish, eggs and dairy products provide enough of all nine essential amino acids to earn the title \`complete proteins'. But plant proteins, like those in vegetables and other plants as well as nuts and seeds, don't. That's why they're called \`incomplete proteins' and need to be combined with one another (or with man-made versions of the missing amino acids) to deliver the right cocktail of amino acids to promote growth in monogastric (single-stomached) animals like fish, poultry, pigs, dogs, cats and, of course, humans.

The same does not apply to ruminants – like cattle, goats and sheep – that have multi-chambered stomachs, chew the cud and use a stepwise, ultra-efficient digestive process to squeeze every bit of energy out of the grain or grass they're fed. These guys can do fine on a diet of plants. They don't need the above-mentioned cocktail of amino acids to get their protein kick. But monogastric animals (let's call them monogasts for short) do. In fact, monogasts like us need a very particular protein mix – and it starts with the kind that's complete.

Clearly, getting enough protein is a human health priority. But how much is enough? According to the Food and Nutrition Board at the US National Academy of Sciences' Institute of Medicine in Washington, DC, an adult human's Recommended Daily Allowance (RDA) or Adequate Intake (AI) is 46 to 56 grams of preferably complete protein per day, or 10 to 35 percent of total calories consumed. That's about equal to one small piece of steak or tin of tuna. But most of us probably want more than that – some experts even estimate that the average American eats double their protein RDA every day.

Like it, want it or need it, complete protein is an integral part of the monogastric diet. We humans take this very seriously. That's why we're very serious about eating protein in the form of dairy products, eggs and, even more so, animals. Lots and lots of animals for the lots and lots of people that populate the planet. And there are more and more of us by the day. Statistics show that humans are in fact responsible for 100 million acts of sexual intercourse daily – that's according to 2011 research by Durex (who better to ask?). The World Health Organisation (WHO) says this leads to about 374,000 births per day, which – if you subtract the 170,000 deaths – means that 204,000 more people sit down for supper every evening than had breakfast that morning. That's like adding New York City's population to the world every month. It's impressive procreation. But also a lot more mouths to feed.

There are 100 million acts of human sexual intercourse every day. There are also 374 000 births and 170 000 deaths, meaning that 204 000 more people sit down for supper each day than had breakfast that morning. That's a lot more mouths to feed.

You see, humans are survivalists. We are very good at finding ways to survive – mainly by thinking up new ways to eat more, build better shelters, have more children and dodge more disease. We are successfully turning the diverse biomass of the planet into human biomass. So how do we produce the number of animals required to feed our ever-growing population's ever-growing need? Industrially, that's how.

Industrial farming is both a boon and a blight. Yes, it allows us to produce vast amounts of affordable beef, chicken, pork, eggs and fish. Yes, it helps us generate more protein in less time. Yes, it's controllable, reproducible and super-marketable – a way to deliver the right food at the right time to our supermarkets, at a price we can afford. But, no, industrial farming is not very sustainable, particularly animal farming. Mostly because you have to put lots of energy and protein in to get not very much of the optimal protein out.

Industrial animal farming is not sustainable. Mostly because you have to put lots of energy and protein in to get not very much of the optimal protein out.

But it's not just us. All animals need protein. Industrially farmed monogasts need `complete' proteins that deliver all the necessary amino acids in the correct amounts. This generally comes from one of two sources: the land or the seas. Soya from the land is 30% protein by volume, but it's also plant protein and therefore `incomplete'. This means it's a less convenient animal feed that needs to be supplemented with additional man-made amino acids. Fishmeal from the seas is 52% animal protein and `complete'. This might be more convenient, but it's far from a sustainable solution. In fact, generating sustainable amounts of either protein is something of an environmental juggling act. As the human population and hunger for protein explode, it's no wonder we're dropping balls.

Soya production demands enormous quantities of water, land and fossil fuel for transport and fertiliser. Fishmeal production, rather obviously, calls for enormous quantities of fish. That's the problem: dwindling natural resources and a growing global demand have driven up the price of both protein sources significantly. But the financial cost is small change when compared to the environmental costs. Especially when it comes to fishmeal.

Fish farming or aquaculture needs 2.3kg of fish to produce 1kg of fish, only 30% of which is consumed by humans – the fillets. The rest is waste.

If it doesn't end up in our pet food, about 30% of all the fish caught from the ocean ends up on industrial farms being fed to chickens, pigs, prawns, shrimp and other fish. In fact, even efficient fish farming or aquaculture operations need 2.3kg of fish to produce 1kg of farmed fish, only 30% of which is ultimately consumed by humans – the fillets. The rest is waste. And that really is a waste. It's something like a 200% protein investment for just a 30% yield. You don't need to be an economist to see that this set-up is a recipe for bankruptcy. And that's exactly what's happening in our seas: not a credit crunch, but a protein crunch.

A quick ecology lesson: Greenpeace estimates that our global fishing capacity is now four times greater than there are fish left to sustainably catch. The United Nations agrees, saying that more than 70% of the world's fisheries are "over exploited," "fully exploited," or just plain "significantly depleted". This is unsurprising, considering that the UN Food and Agriculture Organization (FAO) 2010 review estimates that 145 million tonnes of fish were eaten in 2009. Of this, 55 million tonnes were farmed and 90 million tonnes were caught at sea. According to the review, "115 million tonnes was used as human food, providing an estimated apparent per capita

supply of about 17kg (live weight equivalent), which is an all-time high."

The report goes on to show that aquaculture is the fastest-growing animal-food-producing sector. In fact, it's getting fast enough to outpace our very fast-paced population growth. Per capita fish supply from aquaculture alone went from 0.7kg in 1970 to 7.8kg in 2008, an average annual growth rate of 6.6%. It's also more than a ten-fold increase overall.

A rhino horn will sell for around $440 000. A single blue-fin tuna sold for a record $736 234 at a January 2012 fish auction in Tokyo.

The big, scary numbers just get bigger and scarier. Nearly 30% of all the fish we take from our oceans is used in industrial and farming operations. Now, more than 90% of large predatory fish like cod and tuna is gone. In January 2012, at the first fish auction of the year in Tokyo, a single blue-fin tuna sold for a record $736,234. Granted, the fish weighed 296kg and was bought for high-quality sushi meat. But, if you consider that a rhino horn will fetch merely half that amount on the illegal black market (around $440,000), the scarcity of fish species that were previously staples begins to swim into focus. That's why other species now have to be targeted – which has led to some creative rebranding by the fishing industry. The `Slimehead' is now known as the more appetizing `Orange Roughy' and the `Patagonian Toothfish' as the tastier-sounding `Chilean Seabass'.

And then there's the krill fishing.

Krill are small, pink, shrimp-like crustaceans that eat phytoplankton and are eaten by bigger marine animals, such as fish, seals, whales and penguins. Because these larger animals don't eat plankton themselves, the krill constitute an essential link in the aquatic food chain. Now they're also becoming essential to aquaculture. Why? Because there are fewer fish available to feed to more fish farms than ever before.

Over 75 percent of the world's fish oil and 40 percent of its fishmeal currently go into aquaculture. So say estimates from within the fishing industry itself. Most farmed fish and shrimp need complete animal protein to keep going and growing. But clearly, at this rate, the supply of wild fish cannot continue to meet the industry's fishmeal demand. What's the next-lowest complete animal protein in the marine food chain? It's the krill. So krill oil and meal will just have to do. Conveniently, these feeds are also high in protein, low in pollutants and can help to give farmed salmon its famous colour (boosted by pink dye of various shades). The industry is happy enough to make the change. But the marine ecosystem isn't.

The greatest population of krill is found in the Southern Ocean around Antarctica. As the fishing industry turns its attention to this area, so too do the conservationists. A report in the February 2011 issue of Fishing and Fisheries stated that, for the 17 years leading up to 2009, Antarctic krill fishing was stable at about 120,000 tonnes a year. Since then it's increased to more than 200,000 tonnes, an amount that's expanding as fish stocks continue to decline.

Let's face it – we have eaten from the top of the marine food chain towards the bottom. The human hunger for resources strikes again. When we get to the bottom it's game over – for the oceans and for us. It's no wonder that the Pew Environment Group's Antarctic Krill Conservation Project, part of the Washington, DC-based charitable foundation, says that shrinking krill populations could place the entire Antarctic ecosystem at risk. Research has shown that even localised krill loss can hamper penguin, whale and seal populations. Imagine what it could do on an oceanwide scale.

At least, with enough awareness and planning, the krill crisis may yet be averted. But, when it comes to over-fishing, it could be too late to stem the tide. The regulation of fishing and vessels is lagging pitifully behind the accelerating problem. In 2007 the US- based sustainability foundation, the Worldwatch Institute, in its report, *Oceans in Peril: Protecting Marine Biodiversity*, ventured that our only

option may be to declare 40% of the oceans off-limits for fishing. This will probably never happen – although in 2002 the UN agreed that by 2012, 10% of all oceans should be declared marine reserves in order to protect our fish stocks. Politicians have yet again failed to deliver, even on their own promises. Nevertheless, with or without restrictions, we still have to go ever further and ever deeper to catch the same amount of fish. And this, of course, leads to ever-increasing costs.

In 2006 it took about one litre of diesel to catch 1kg of fish. Now it takes two litres of diesel, which itself is ever more expensive due to rising fuel prices. If we want to keep generating enough protein to support the human need, we simply must find something more sustainable to feed the process. Evidently, a new complete protein sourcedesperately needs to be found. One that costs less than fishmeal, both economically and environmentally.

Sustainable aquaculture, according to Greenpeace, involves monitoring both what you put in and what you get out. The input shouldn't lead to the depletion of natural resources, or the use of fishmeal or fish-oil feeds from unsustainable fisheries. Similarly, the output shouldn't result in environmental damage or a net loss in fish protein yield. That's why sustainability-conscious fish farmers are being forced towards using plant-based feeds that are sustainably grown themselves – at least for mainly vegetarian fish (like tilapia or barramundi) if not for carnivorous, protein-eating salmon and trout.

But switching to plant feeds like soya is not an ideal solution. Firstly, its production comes with its own costs and challenges, and secondly, soya protein is `incomplete' as it is missing certain vital amino acids in the protein mix. This means that farmed poultry and pigs that are fed soya need to get a side-order of additional man-made amino acids to make their protein supply `complete'. Fish like salmon and trout, and crustaceans like prawns, can't be grown on this artificial mix and need animal protein with its higher concentration of complete protein to grow successfully. Clearly, it's a conundrum: the animal protein we need is not sustainable, but the plant protein we can get is not quite interchangeable and just won't work in aquaculture.

But what if sustainability could be achieved with another kind of animal protein? What if that protein was complete, but also completely sustainable? What if this protein could be generated using waste products from the animal industry itself? Well, it can. But, again, it depends on what you put in and what you get out.

The search for sustainable farming calls for a bit of recycling. In this case it's nutrient recycling – using free waste products to generate valuable food products.

In any industry, the search for a better input-output balance calls for a bit of recycling. In this case it's nutrient recycling – using `free' and existing waste products to generate valuable food products. The key is finding something to do that regenerating, and it helps if that something is built to do the job.

Which brings us back to the fly, more specifically *Musca domestica*, or the common housefly. It really is one of the most common insects worldwide. It's found on every continent in every environment and it multiplies in massive numbers to keep things that way. The house fly is a survivalist. In short, it's just like us. It's an excellent breeder – a female will lay up to 800 eggs in her lifetime, usually in some kind of warm organic material or waste. These eggs hatch into larvae, which take just a few days to expand over 400 times in weight. Unless they're eaten before that.

You see, fish and birds love to eat flies and larvae. Chickens will naturally peck around in the dirt for them and fish will jump out of streams to grab at them. Why? Because larvae are protein powerhouses. Nutritionally speaking, they're more natural than and at least as good as fishmeal. And when it comes to soya they're more sustainable and certainly more complete. You can see where this is going. Waste plus flies equals larvae plus protein.

Fish and birds love to eat flies and larvae. Chickens naturally peck around in the dirt for them and fish will jump out of streams to grab at them. Why? Because larvae are protein powerhouses.

This kind of organic alchemy was first attempted in 1919 when a biologist named Lindner started tinkering around with houseflies and human waste. His rather off-putting study involved feeding sewage to fly larvae and watching them grow. And it worked – as in nature the larvae thrived, but (not as in nature) instead of being allowed to turn into pupae, the larvae were harvested, dried and converted into a useful protein source. Although no one knew quite how useful just yet.

Research into flies and their lifecycle reached new highs in Europe during the 1930s and 1940s – driven mostly by wartime fears and food security concerns. Then in 1969 three researchers at Ohio State University in Columbus, Ohio – CC Calvert, RD Martin and NO Morgan – used poultry waste and houseflies to generate their own dried fly pupae protein. This they fed to baby chicks for their first two weeks of life. The conclusion: this fly-generated feed contained enough high-quality protein to support normal growth and development. A triumph for the research trio, but one that was still never actively pursued. The economics of production at the time just didn't add up.

It makes sense, really. Flies like waste and animals like flies. Therefore, if waste from the animal protein industry – like blood and offcuts from abattoirs – can be fuel for flies, then fly larvae can be an efficient fuel for the animals in the fish and meat industry itself. It's a sustainable circle. A self-supporting cycle of nutrients begetting nutrients in a loop.

Nature is full of these circles and loops. One organism's waste is another's favourite food. That's why, in the natural world, everything balances out and so little ends up going to waste. Perhaps it's time we slotted into this cycle by following a species that's naturally smart and sustainable – like the fly.

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Flies may not make great pets, but that doesn't mean they can't improve our lives. Not just agriculturally, but also environmentally, medically, scientifically and even recreationally (which has nothing to do with tying them to a piece of string). That's what this book is about – seeing flies as much more than they appear to be.

It's time to look a little closer at these alleged pests. It's time to investigate their good, their bad and their ugly. You might be surprised at what you find – more good than bad, and a pretty useful kind of ugly, too. The truth is, flies are here to stay and we should start appreciating how and why they are. The truth is, life wouldn't be a picnic without them.

CHAPTER 2

FLY AS ENEMY

IT'S PROBABLY THE MOST FAMOUS fly swat in history. The date: June 2009. The scene: a television interview with CNBC. The swatter: interviewee, US President Barack Obama. The script: "That was pretty impressive, wasn't it? I got the sucker." Verbatim.

As the camera swung to the dead fly on the floor, the splat echoed across the world through airwaves, newsfeeds, Internet cables and reporters' over-eager puns. Even People for the Ethical Treatment of Animals (PETA) had something to add.

"Well, I guess it can't be said that President Obama wouldn't hurt a fly," blogged PETA representative Alisa Mullins. "In a nutshell, our position is this: he isn't the Buddha, he's a human being, and human beings have a long way to go before they think before they act."

> "That was pretty impressive, wasn't it? I got the sucker"
> -- Barack Obama

Mullins went on to say that PETA was sending a "humane bug catcher" to Obama, "for future insect incidents". It's called the Katcha Bug – a plastic dome with a handle and a clever shutter mechanism.Basically, you place the dome over the fly on a flat surface. Then a quick twist makes the shutter drop and traps the fly inside, unharmed and happy to be released out the White House front door. Mission accomplished. Insect incident avoided.

Whether or not the President has gone from SWAT team to Katcha Bug is still unknown. What is known, however, is that it wouldn't make a speck of difference either way.

Humans have been squashing, spraying and swishing away flies for all of recorded history. Not without just cause. Flies have been bugging humans for just as long, if not longer. The fourth of the Bible's Ten Plagues was a rampant swarm of flies, and ancient Egyptian hieroglyphics frequently show pharaohs followed closely by court officials armed with fly whisks. Greek mythology also made mention of the pestilent pests – a dedicated god called Myiagros was assigned the role of shooing away flies before sacrifices to Zeus and Athena (clearly not the most important god on the block, but still a job considered worthy of divine intervention).

So, if humans have been trying to kill flies for as long as the two have shared the planet and hot meals, why are there still so many of them? Truth is, there aren't. At least there aren't as many as there could be.

> One pair of flies could easily spawn six to seven generations and 200 quintillion offspring in just five months. If none were killed or eaten, that would be enough to blanket the entire Earth with a layer of flies 47-feet deep.

Left to their own devices, a couple of loved-up flies could easily spawn six to seven generations and 200 quintillion offspring in just five months. There's a bit of debate as to what exactly constitutes a quintillion – in Britain it's a 1 followed by 18 zeroes, and in the US a 1 followed by 30 zeroes (of course everything is bigger and better in the States). But, number of zeroes aside, scientists estimate that the above-mentioned pair of flies' unchecked breeding would be enough to blanket the entire Earth with a layer of flies 47-feet deep. In only five months! Fortunately, according to research performed by University of California entomologist Fred Legner in the 1960s, this could never happen. Too many animals eat or kill flies – including us – meaning that the insect's population is naturally limited or controlled by around 98%.

Bernard Greenberg, international fly authority and professor of biological sciences at the University of Illinois, agrees that fly numbers are pushed down by many possible forces. These include natural predators – like birds, reptiles and other insects – as well as a number of environmental factors. In fact, flies and their progeny are very thin-skinned and sensitive when it comes to their surroundings. They need the right supply of the right kind of food.

They need optimal moisture levels and precise temperatures to keep mating, laying eggs, growing rapidly and metamorphosing from egg to larva to pupa to fly.

Temperature is probably the thing they're most persnickety about. Because flies are essentially tropical creatures, they do better when it's warmer. At 10° or 11° C they lose the ability to fly. At 7° they just about lose consciousness. And at even a touch below freezing they're dead in a couple of hours. They're also dead if the temperature climbs above 46° or 47° C. In fact, they're happiest and most productive (read: reproductive) when it hovers around the early 30s.

But, despite these sensitivities, flies are still ubiquitous. The housefly, in particular, is found all over the world. It can survive the harshest winter in the iciest clime, as long as there's a human house, barn, hut or hovel in which to hide out and keep warm. That said, fly fundi Greenberg thinks that Africa is the cradle of both human and fly-kind alike. That's probably why the African continent is home to the largest number of fly species and sub-species. But it's also home to the greatest risk of fly-borne diseases – which brings us to the real reason flies and humans are not likely to stop killing each other any time soon.

> The housefly can survive the harshest winter in the iciest clime, as long as there's a human house, barn, hut or hovel in which to hide out and keep warm.

HOW DO FLIES KILL HUMANS ?

Dysentery, typhoid, cholera, salmonella, poliomyelitis, tapeworm. Eye infections like trachoma and conjunctivitis. Skin infections like yaws, cutaneous diphtheria and leprosy. It's not a nice list, and not a nice lesson. The lesson is that all of these diseases can be picked up and passed on by flies. In fact flies make particularly good taxis for disease-causing organisms on the move. Why? Because they have a taste for both organic waste and human food. A taste that drives them hungrily from dung pile to dinner plate, collecting passengers on one side and delivering them on the other.

No prizes for guessing why someone came up with the term `filth flies' to describe a group that includes the housefly, blow fly, bottle fly, flesh fly and sometimes the drain fly, fruit fly and phlorid fly. Clearly they all like to eat, loiter around or breed in some form of filth. And it's the unique way that flies are designed to eat, loiter and breed that makes them the efficient disease vectors they truly are.

Let's look closer. While loitering on infected excrement or anything that's started to decay, the fly encounters a disease-causing microorganism. This organism might attach itself to the fly's body – in which case it will survive for only a few hours – or it will be eaten and enter the fly's gut, where it persists for a number of days. Either way, this fly is now cocked and loaded to shoot off disease.

A fly has no biting gear, so it can eat things only in fluid form. When landing on a solid food it spits out some stomach contents and dissolves the meal into something that can be easily sucked up. But something is always left behind.

Perhaps the fly then lands directly on you – or, more indirectly, on your next meal. And perhaps the organism on board is still alive and able to infect a human host. If so, it can either be rubbed off, or excreted out of the fly's body. And the fly's characteristic way of eating helps the infective process on its way.

A note on fly physiology: because it has only a feeding tube, or proboscis, and no biting gear in its mouth, a fly can eat things only in fluid form. This means that solid or semi-solid foods have to be liquefied first. So, when finding itself on a chicken drumstick, cupcake or mound of mashed potato, the fly uses its proboscis to spit out some of its last meal – possibly, or probably, consumed on manure pile or landfill.

This regurgitated surge contains stomach contents and digestive juices that mix with and dissolve the solid cupcake into something that can be more easily sucked up. But something is always left behind. Something from the manure pile. An infective stowaway that could make you sick.

This is not to say that flies are solely responsible for the spread of infectious disease. No, they're not that good. Often the microorganisms are too delicate to survive the flight, and in many cases transmission happens more directly through human-to-human contact or contaminated water or food. But researchers and public health pundits still agree that flies pose a significant health problem, especially in areas where refuse-removal is below par and filth is more likely to accumulate. The very presence of flies can be a sign that conditions are less than hygienic. And the more flies, the less hygienic they probably are.

More garbage and waste will attract more flies and more disease-causing illnesses. Some scientists say that one slum-dwelling, urban fly could carry up to 33 million bacteria within its gut and then half a billion more on the outside of its body.

Think about it. More garbage and waste will attract more flies and provide more disease-causing bugs for them to pick up and carry around. This suggests that more sanitary areas will actually be home to cleaner flies. And they are. It's been established that a single fly can be home to more than 1.9 million bacteria, which is bad enough. But some scientists say that one slum-dwelling, urban fly could be carrying up to 33 million bacteria within its gut and then half a billion more on the outside of its body. This is like an overpopulated bacterial slum living on and within a fly that itself lives in an overpopulated human slum full of people who also carry billions of bugs on and within their bodies (thankfully the immune system ensures that these are mostly the good sort).

The mind truly boggles. Considering the billions and quintillions being thrown around, it seems clear that fly infestations and fly-borne infections are more of a challenge in developing countries and communities. But developed areas and sanitised streets certainly aren't immune. Flies don't stick to one neighbourhood, they move around – within a range of up to 24 kilometres – especially if the wind picks up and gives them a push.

Plus, in any numbers, flies are always annoying. Even a single fly buzzing around a quiet kitchen is enough to spoil both the cook's mood and the broth. Unsurprising, then, that `nuisance flies' is another semi-official title given to various groups of flies (including the housefly) that harass humans and animals through buzzing, biting and spreading disease. Nuisance flies. Filth flies. Say no more. It's all in the names.

Humans have spent hundreds or even thousands of years working on ways to kill and control flies. Which is not to say that it's worked. Despite all our time and energy, the housefly and its friends are still here and here to stay.

But flies don't just have bad PR. The facts are there. The evidence clearly shows that they really are a personal nuisance, public health hazard and potential human foe. They can't help it. It's how they're made. Maybe that's why humans have spent so much time and energy finding ways to take them apart. Which is not to say that it's worked. Despite all our time and energy, the housefly and its friends are still here and here to stay.

There was a brief period, post-World War II, when flies in homes, farms and restaurants were targeted with lashings of chlorinated hydrocarbons and DDT. A heavy-handed approach, to say the least – akin to burning down a log cabin to combat a termite problem. Yes, the toxins did put a damper on fly populations. But they also poisoned people, animals, beneficial insects and entire

environments, while pushing surviving flies to develop immunity to the toxins' effects.

So the search for meaningful fly control continues. It's a testament to the insect's ability to fly in the face of our most vicious and valiant scientific eradication plans.

HOW DO HUMANS KILL FLIES ?

There may be 50 ways to leave your lover, but for the purpose of this book, there are only 10 ways to kill a fly. The methods can be physical or chemical, smart or a little messy. A 2004 fly control report by the World Health Organisation says that larger-scale, longer-term results call for preventative measures like better sanitation and improved hygiene. But, in the meantime, let's examine the 10 options available to us now, in no particular order.

1. The flyswatter

Technically it's a rectangular piece of metal or plastic mesh attached to the end of a stick. More often than not it's whatever happens to be on-hand – a rolled-up magazine, tea towel or (as in Obama's case) a fast, flat palm.

In some form or another, the swatter is probably the oldest weapon in the fight against flies. The makeshift, make-do ones have been around forever and are pretty good at getting the job done. But the official flyswatter is thought to have made its debut in 1905 in the state of Kansas, USA.

"The fly is the disseminator of the three Ds: Dirt, Diarrhoea and Disease, which often result in the three Ts: Typhoid, Tuberculosis and Toxins; and which should teach us to cultivate the three Cs: Care, Caution and Cleanliness"
-- Dr. Samuel Crumbine, State Board of Health, Kansas, USA, 1905

At the time, the state was suffering an influx of flies. A member of Kansas's State Board of Health at the time, Dr Samuel Crumbine, responded with his first so-called Fly Bulletin: "The fly is the disseminator of the three Ds: Dirt, Diarrhoea and Disease," it said, "which often result in the three Ts: Typhoid, Tuberculosis and Toxins; and which should teach us to cultivate the three Cs: Care, Caution and Cleanliness..."

Crumbine's smear campaign, based out of Topeka, was as punchy as it was persuasive. "[Window] screens are cheaper than doctor bills," he preached, and even tried his hand at poetry: "I never wash my feet; But every single chance I get I walk on what you eat. Buzz, buzz, busy fly."

It was the Wild West for flies – but wilder. Especially when Crumbine started offering rewards for dead flies. A local teacher named Frank Rose heeded the call and encouraged his Boy Scout troop to help screen people's windows and make `Fly Bats' using offcuts of screen nailed to yardsticks. When Crumbine saw this invention, he grabbed the concept with both hands and ran with it. But he named his version the catchier `Fly Swatter' after hearing a fan yell, "Swat that fly!" to a ball batted clear over the fence at a local baseball game.

Crumbine's creativity didn't stop there. He commissioned films about fly villains contaminating babies' milk. He arranged macabre `fly parades'complete with crowds of people, baskets of dead flies, giant flyswatters and children dressed up as flies pushing baby-carriage coffins down the street.

In 2005 a high-tech fly swatter was invented -- an electric tennis racquet-like device that fries the fly with a couple of thousand volts as it swats.

The parades were a just a phase. But the flyswatter clearly was not. Since then, it's found a place in many modern homes and has even led to high-tech versions like an electric tennis racquet-like device that fries the fly with a couple of thousand volts as it swats.

Another offshoot, the fly gun, promises to squash the fly in mid-air by shooting out a spring-loaded, perforated plastic disk on a string.

But the basic swatter-on-a-stick variety still stands the test of time. It's thought to be a far better weapon than any flat hand or rolled-up magazine. The holes in the mesh surface allow a faster swing and fewer changes in air pressure and airflow – sensations that the fly usually senses in time to escape.

2. Sticky stuff

First there's fly tape – a roll of stickiness that's sure to ruin your appetite even if it does deal with the flies. It's usually found hanging in the centre of a room that commonly attracts flies – like a kitchen – and it's usually covered with flies in various stages of death and its preceding throes. Yes, fly tape gets the job done well.

Waste management sites can collect as many as 150 flies per flypaper in a 30-minute period.

It's designed to be suspended from the ceiling, and might contain some sugar to attract the flies. Once they're stuck, it's certain (if not immediate) death and the tape will last as long as the surface isn't covered with dust or dead flies. According to the University of Florida's Department of Entomology and Nematology, while flypaper is strung up for the smallest numbers of flies, waste management sites can collect as many as 150 flies per flypaper in a 30-minute period – thankfully most home versions don't need to work nearly as hard.

Then there are sticky boards, or glue boards, which rely on the same principle, but are often placed inside traps. This is a convenient way to keep trapped flies neatly stuck away and hidden from view. Plus, for more frugal fly killing, some boards can also be washed and reused.

3. Fly traps

There are many manifestations, but the concept is consistent: irresistible bait, inescapable fate. Whether it's an old-style, glass fly bottle, a newer-fangled, plastic trap or a large, outdoor construction made of fine gauze and wood, the structure always has a very small entry hole leading into a large attractive space for breeding and feeding. That's where you place the bait, which could be anything from meat to sugar or, preferably if outdoors, decomposing kitchen waste, meat, or fish.

The trick is in the effectively one-way entrance. Once the flies find their way through the hole, they can't seem to work their way out again. Some fly-bottle traps even position the hole in a narrow black metal top. Flies are positively phototaxic, or attracted to light, and therefore to any area of the trap except the dark-topped way out.

Other versions take things a step further by including a trough filled with vinegar, beer or a blend of milk, water and arsenic that the trapped flies will drown in. But, whatever form it takes, a trap is generally a very useful way to catch large numbers of flies. As long as you don't mind having to empty out those dead flies (and maggot-ridden bait) after a week or so.

4. Fly zappers

The bug zapper's earliest ancestor was probably an `electric death trap' invented in 1911. A piece of meat was used as bait to lure flies towards a light bulb surrounded by 450-volt wires.

Official people and scientists sometimes call them Devices for Electrocuting Flying Insects, or DEFLIs. But that doesn't make them any more effective. In fact, a study from the University of Notre Dame in Indiana, USA, recently showed that there was very little difference in the number of flies and mosquitoes found in homes with bug zappers than in those without.

This could be because the DEFLIs electrocute other insects more often than they do mosquitoes and flies. No matter. The devices do still have their place – mostly in hospitals, restaurant kitchens and porches belonging to eerie old guys in the movies. And they are

quite cunning – the bugs are attracted to the light (through phototaxis again), so they fly towards it, touch two high-voltage wires and get promptly electrocuted with a short, sharp `zap'.

The DEFLI's earliest ancestor was probably an `electric death trap' invented by two anonymous Denver, Colorado, men and featured in a 1911 issue of Popular Mechanics magazine. A piece of meat as bait was used to lure flies towards a light bulb surrounded by 450-volt wires. But despite successful electrocutions and some positive press, the zap trap didn't catch on until 1934 when two different inventors in Rochester, New York, William F. Folner and Harrison L. Chapin, patented a fluorescent light encased in electrified wire mesh. Theirs is the invention that led to the zappers of today.

Despite this long history and their hardcore fans, the fact remains that DEFLIs don't make good solutions for fly problems. The World Health Organisation thinks they work better as part of an integrated fly-terminating programme. Most eerie guys on porches will probably agree.

5. Pheromone traps

Sex sells, but it also smells. It smells like pheromones – physiological chemicals, produced by an insect or animal to send signals to other members of its species. They're like cologne, but more effective. They might not smell as strong, but they're far more irresistible. Like cologne, pheromones are designed to sell sex – by subliminally advertising an animal's sexual readiness in order to attract an appropriate mate. No one's really sure if humans produce or respond to them. But flies do. And this can be their undoing.

Sticky traps can be treated with synthetic fly sex pheromones. These natural- scented chemicals lure the fly closer in search of the mate that can be sensed but not seen. It's quite an anticlimax. The fly is stuck and remains so until it dies.

That's what happens when you add some synthetic fly sex pheromone to a sticky board or trap. An olfactory urge lures the fly closer in search of the mate that can be sensed but not seen. What follows is quite an anticlimax. The fly sticks to the board and may remain so for a day or two until it dies.

Not a great way to go. It's all morning-after, with no night-before to show for it.

Pheromone traps are very sensitive (to their targets, if not their targets' feelings). They don't work well for large numbers of flies, but are great for attracting specific breeds in low-density areas. Plus you can seduce a fly only with a specific fly pheromone – so you know your trap won't attract and conquer every insect in the area.

The downside? They're generally single-sex operations. You can't lure male and female flies with a one-size-fits-all scent.

6. Pesticides and poisons

You can spray flies with an aerosol or pump – directly onto the fly, into the air or onto any possible landing surface. You can diffuse it in a fine mist into a warehouse or barn. You can soak it into curtains, gauze, bed nets or strips of paper (in the old days they poured it into bunches of twigs). You can even blast it through an area with a chemical fumigation bomb. You can use it in liquid form or as a solid dust. You can choose a quick killer or one that slays slowly over time.

In short, when it comes to flies you can have your pick of poisons. Yes, they work. But the problem with most of them is that they work on everything else, too. This can include other insects, animals, plants and any air, soil and water that might be exposed. It can also include humans who get too close.

Most common fly sprays work by inhibiting nerve signals and sending the fly into a state of paralytic contraction and fatal asphyxiation.

They generally contain a strong toxin called Dichlorvos – since the US Environmental Protection Agency (EPA) first assessed its use in 1981, this chemical has almost been banned many times and for many reasons. It's been accused of being carcinogenic and of causing acute and chronic toxicity. It's also been linked to a possible increased risk of Attention Deficit Hyperactivity Disorder (ADHD) in children.

The other problem is that flies are speedy breeders with short lifespans. This makes them very good at developing resistance to common pesticides. What doesn't kill them makes them stronger. But it still kills or compromises the less resistant creatures in the area.

7. Toxic baits

A spoonful of sugar makes the sodium arsenite go down – "in the most delightful way". Well, sort of.

Traditionally, toxic baits mix sugar water or milk (which flies love) with strong toxins like sodium arsenite, organophosphorus or formaldehyde (which they definitely don't). Milk and sugar may be tempting, but they don't attract flies from afar – especially if there's lots of more attractive food around. It has been found that using different baits helps to lure flies over longer distances. These include fermented yeast, malt, syrup, animal protein like egg, and synthetic fly attractants or pheromones.

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Toxic baits can be liquids, solids or paint-on varieties applied to fly-frequented walls, posts, windows, wires, cords or ceilings. The benefit is that they can keep working for a couple of weeks. Plus they're less likely to lead to resistance – interestingly, flies that have become immune to a particular toxin in spray-form can still be killed when it's used in bait-form.

8. Venus flytrap

When Venus shuts her trap, an airtight seal forms to keep digestive fluids in and any opportunistic bacteria out. It takes 5 to 12 days for the leaves to reopen – depending on the size of the insect.

What list of fly traps would be complete without this one? It might not kill flies in large numbers or at high speeds, but any plant that can attract, catch and digest a quick and quick-witted insect deserves mention. More than that, it deserves to be named after the Roman goddess of love. Which it is.

Just like other plants, the fly-trapping Venus gets food from the air, soil and her own photosynthetic process. But because she usually grows in acidic, nutrient-poor soil – and is found naturally in only a small boggy region of North and South Carolina in the US – she needs to supplement her diet with something. This something could be spiders, flies, caterpillars, crickets, slugs or anything else that crawls into her open-mouthed leaves, which secrete a sweet and tempting nectar to ensure that they do.

Once the something has found its way in, it invariably comes into contact with some short, sharp cilia, or hairs. These are ultra-sensitive motion-detectors – impervious to inanimate objects, they respond immediately to any crawling or wriggling that stirs one or more of them repeatedly or in quick succession. No one is sure exactly how, but this cilial movement causes a chemical reaction that makes the plant tissue relax and the two lobes swing towards one another. This takes about a second. But there has to be movement. That's why delivering a self-swatted fly to Venus isn't enough – you have to move it around within the trap before she accepts the sacrifice and eats.

This goddess also knows exactly what she wants to eat and won't be satisfied with anything else. Flies fit the bill perfectly because of their size and composition. That's why, when the leaves swing closed they remain slightly open for a few seconds to allow

smaller insects to escape – they're just not worth the effort. Also, if an inedible object happens to fall in and trip the trap, the leaves will open after about 12 hours so the leaf or stone can be `spat' out.

If and when she gets what she ordered, Venus shuts her trap tight. An airtight seal forms around the meal to keep the digestive fluids in and any opportunistic bacteria out. It takes 5 to 12 days for the leaves to reopen – depending on the size of the insect – but when Venus is done digesting, nothing remains except perhaps a tough insect exoskeleton that will be washed or blown away.

Clever, carnivorous Venus. She might be endangered in the wild, but – like the flies she hunts and eats – she has also evolved to survive. Now this plant has become a collectors' choice and a source of sport. She even has humans catching and hand-feeding her flies in their homes. Not too demanding. Two a month is generally enough.

9. Fly predators

For $20 to $30 you can buy one unit of parasitic wasps online. That's about 10,000 fly pupae infected with wasps and packed in a paper bag full of sawdust. Plus they'll ship anywhere. Sounds like a bargain. If you know what to do with them.

This is called biocontrol – the agricultural management of one pest (like flies) using another pest (like wasps). It's a smart system because it exploits the natural hunter-prey relationship. When flies are the proposed prey, hunters of choice can include several predatory beetles and mites, or else the tiny parasitic wasps that love to take over fly pupae.

It's called biocontrol – the agricultural management of one pest (like flies) using another pest (like parasitic, pupae-infesting wasps).

Many insectaries specialise in breeding and selling these wasps. And many farmers buy them because they make a great fly-control workforce. Parasitic wasps will work against the housefly, lesser housefly, biting stable fly, blow fly and bottle fly. They also reduce

Parasitic wasps are biologically drawn to fly pupae and larvae about to pupate. They can travel 30 to 50 metres to seek out and infect a host, even at a depth of up to 20 centimetres in manure.

or eliminate the need for unnatural insecticides – particularly useful on farms where humans, animals and crops risk toxic exposure.

The safety features continue. These wasps are host-specific, meaning any exposed humans, animals and crops are perfectly safe. Also, they want fly pupae and not much else – they're biologically drawn to the pupae, as well as to larvae that are about to pupate. In fact they can travel 30 to 50 metres to seek out and infect a host, even at a depth of up to 20 centimetres in manure (the birth and growth place of many flies in farm environments).

When a wasp finds a pupa, it breaks open the shell and lays an egg inside. The pupa dies on exposure to air, and when the wasp egg hatches the pupal juices and remains make a convenient source of food. Adult wasps also feed on fly pupae fluid – they eat twice during their 16 to 28-day adulthood and will reproduce as soon as they leave the puparium, laying 6 to 350 eggs a day, which yield more natural born killers to join the fray.

This safe, sustainable and self-renewing workforce is similar to those produced by Integrated Pest Management or IPM companies like Oxitec. Like the parasitic wasp producers, they breed insects to manage pests. But, in this case, they breed the pests themselves – more specifically, pest insects that carry disease or damage crops, such as mosquitoes and fruit flies, respectively. During the breeding process, fancy, biotechnological interventions produce sterile males that are released into the environment to mate fruitlessly with wild females and keep populations in check. It's a highly targeted form of biocontrol that's adding its clout to the pesticide fight.

And it's a fight that's ongoing. The biocontrol industry as been growing since the 1950s when the first murmurings about long-term

pesticide dangers were heard. The US Agricultural Research Service estimates that since 1953 this approach has saved more than $2 billion in pesticides. That said, according to Oxitec, despite the use of around $8 billion of pesticides a year, insects still claim at least 20 to 40% of the agriculturally grown food. Clearly, there's still an important place for pest management using pests. For parasitic wasps that place is within the fly pupae they know and love.

Despite the use of around $8 billion of pesticides a year, insects still claim at least 20 to 40% of the agriculturally grown food.

10. The Obama method

You don't need to be the President to successfully swat a fly. But being a scientist might give you an edge. Just ask fly bioengineer and professor at the California Institute of Technology, Michael Dickinson – although, after 20 years spent studying fly aerodynamics, the Prof. is probably quite tired of being asked how best to squash the subjects he studies so hard.

In 2008, Dickinson (`Flyman' to his friends and according to his official university email address) used high-speed, digital videos of fruit flies to assess their swatter-dodging ability. His research, published in the journal Current Biology, showed how this escape reflex is hardwired into the fly brain and allows it to react within 100 thousandths of a second.

First the fly brain calculates the location of the incoming swatter and – depending on its angle of approach – immediately positions its legs, wings and centre of mass for an optimal leap out the way. Fortunately (or unfortunately for the swat-wielder) the fly has a near 360-degree field of view that makes sneaking up difficult (although not impossible).

If the threat comes from up ahead, the fly's legs and weight are arranged to push off backwards – vice versa if it approaches from behind. A swat from the side leads the fly to lean and then jump in the opposite direction. "The fly somehow 'knows' whether it needs to make large or small changes to reach the correct preflight posture," says Dickinson. And the result is a super-speedy getaway from spider, bird, lizard or striking human hand.

Nevertheless, on-target swatting is as simple as anticipating the very speed that makes the fly likely to evade your swat in the first place. Dickinson explains that the aim is to aim a little ahead of the fly's starting position. In other words, go for the direction you know the fly will leap to avoid your swing.

Flyman also has the following tips for more effective swatting:

- **Think before you swing.** Before swatting, approach and position the swatter slowly. Then swing fast.
- **Go back to front.** The fly can see almost full-circle around itself. The operative word is `almost'. Visibility isn't 100% percent in the rear, so it's always better to approach from behind.
- **Use a matching swatter.** A neutral-coloured fly swatter (as opposed to a dark or bright one) will blend in with the background more.
- **Don't swat on the move.** To improve your chances, take your aim and make your move when the fly is stationary – when in flight it can change course in just 30 thousandths of a second.

Despite these swatting tips, Dickinson's work is not really about killing flies. Rather it's about what we can learn from the insect's unique abilities (read more about his robotic flies and their aerodynamic lessons for man in Chapter 6). One of these most impressive abilities is an incredible capacity to survive. Which brings us once again to the reason humans have to try so hard to kill flies in the first place.

In an attempt to understand their drive to survive, Professor Emeritus Andrew Beckenbach from Simon Fraser University in Canada has used fly DNA analysis to paint a picture of the species' evolutionary history. It's a panoramic picture that spans 250 million

years, and is part of an even broader effort to understand the evolutionary tree of which we are all a part. One thing is certain: flies constitute an important branch of this tree. According to Beckenbach they make up 7.5% of all species known to man.

Flies seem to defy mass extinctions. The most recent one swatted dinosaurs from the Earth around 65 million years ago. But at the time flies thrived.

Beckenbach's fly family portrait was published in the journal *Proceedings of the National Academy of Sciences* in March 2011. It shows that there have been at least three episodes of fly adaptive radiation, or adaption of one ancestor species into a number of new distinct species. The most recent radiation started about 65 million years back and ended (or rather continues) in `modern' species like the housefly and fruit fly.

But more interesting is the fact that flies seem to defy mass extinctions – like the last one, which swatted the dinosaurs from the Earth around 65 million years ago. Beckenbach notes that flies didn't just survive this large-scale, multi-species destruction. On the contrary -- at the time, they thrived.

Clearly, flies predate humans and survived the dinosaurs. They can outfly, outbreed and outlast our best brains and most brilliant poisons and traps. They reproduce in quintillions, carry bacteria by the billions and take human lives by the millions upon millions, just by doing what they do.

They defy mass extinctions and continuously deny scientists, Presidents and Secretaries of Public Health the pleasure of their permanent demise. Despite our greatest efforts, there are always more flies. We treat them like enemies, but they're part of a perfectly balanced system of mutual destruction and bilateral need. Yes, we kill them, but still they need us (and our waste) to survive. Turns out our survival might depend on them, too. Perhaps we should start seeing them as friends.