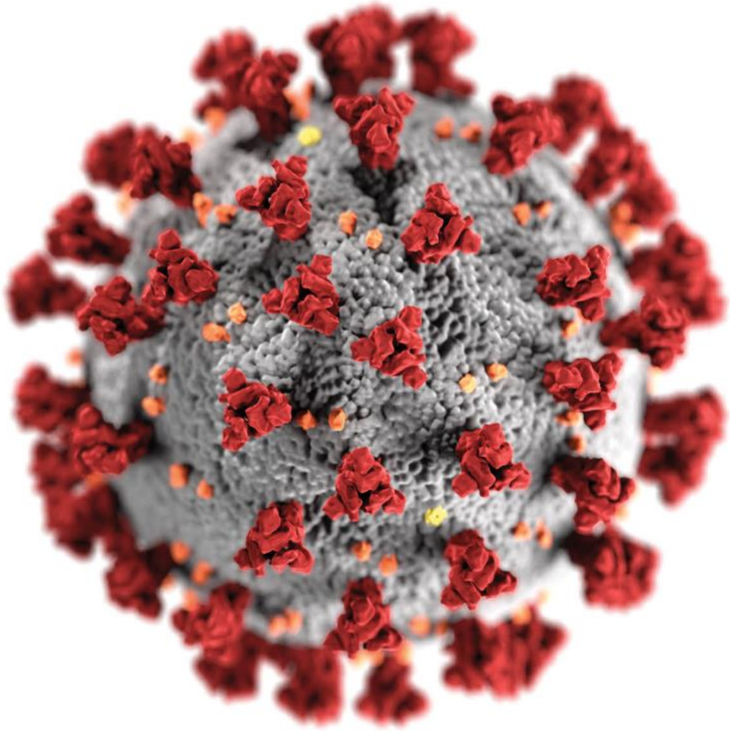
FROM THE AUTHOR OF *THE HAN AGENT*

THE COMING PANDEMIC

CONSPIRACIES, EMERGING INFECTIONS, AND VACCINES

A THINKING PERSON'S GUIDE TO THE WUHAN CORONAVIRUS



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The coming pandemic

Conspiracies, Emerging Infections, and Vaccines

A Thinking Person's Guide to SARS-CoV-2

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Introduction

Coronavirus is coming. By the time you read this, it may already be circulating in your community.

Because I'm a microbiologist who writes science-based thriller novels, epidemics and pandemics are something of an obsession for me. In particular I've devoted a lot of research and imagination to the question of how microorganisms mutate naturally or how they could be altered in a laboratory. I've analyzed the various genetic changes a virus would need to start a pandemic. Then I applied this research to my thriller novels THE HAN AGENT (flu) and REVERSION (rabies), both of which involve viruses that mutate or are manipulated in ways that make them an emerging threat. (My other novel PETROPLAGUE dramatizes a similar phenomenon in bacteria.)

In essence, my novels are stories about emerging infections like SARS-CoV-2, the official name given to the Wuhan coronavirus.

So I've closely followed the outbreak of a sudden acute respiratory syndrome (SARS) in the city of Wuhan in the province of Hubei, China, since it came to light in early January 2020.

People who know my expertise have been asking me a lot of good questions. So I decided to publish my answers here in a format similar to the science journalism I've done in the past. What I bring you is **my unique perspective as a microbiologist, an educator, and a novelist who's been thinking deeply about plagues and their human consequences for a long time**.

I'll help you understand how a virus could just appear like this, and I'll discuss the conspiracy theories that ascribe a non-natural origin to the COVID-19 disease. I'll do my best to put this pandemic in perspective and to predict what's going to happen next, including details about development of a coronavirus vaccine. And of course I share practical tips about what you can do—including a microbiology-based suggestion that you probably won't find anywhere else.

First Impressions: We're in trouble, or hype?

Let's start with something positive. Humans have done some pretty amazing stuff in the first weeks of the SARS-CoV-2 / COVID-19 outbreak.

My initial reaction was, modern bio-science is awesome. Scientists identified the causative agent as a coronavirus, and sequenced its entire genome, almost immediately. This made it possible to quickly develop a test—critical for epidemiologic study and for efforts at control. Sequences of different isolates of the virus are being shared on the internet in real time, allowing us to track how the coronavirus changes and evolves. Compare that to the last great pandemic, the 1918-19 influenza, when *we didn't even know what a virus was*.

My second impression was, we're in trouble.

It soon became clear that **the Wuhan coronavirus spreads relatively easily from person to person**, in a way similar to common colds and flu.

My *uh-oh* moment was when the Diamond Princess cruise liner became the largest "country or territory" of infection outside China in the World Health Organization daily update. Clearly this new virus was far more contagious than its predecessors SARS and MERS (more on those later).

The Chinese made a herculean effort at containment, trampling on civil rights and relying on the cooperation of a populace used to being managed and monitored. They succeeded in slowing the spread of the virus, but with this type of infectivity in a population with no immunity, it can't be stopped without a vaccine. Even with the best current biotechnology, a mass-produced vaccine against SARS-CoV-2 is months or years away.

I became convinced this virus would trigger epidemics around the world—in other words, a pandemic.

I've heard people say it's all overblown hype. In a way, they're not wrong to feel this way. We don't have enough information to make 100% accurate predictions of how the virus will behave. A good analogy is hurricane forecasting. Until it makes landfall, no one knows for sure where that will be. But we can make a highly educated guess. Same with SARS-CoV-2. Based on the infectivity, the method of spread, and the lack of immunity in humans, it looks like the virus will become a pandemic.

Is that hype? Depends on your point of view. The one thing we can say for certain is that hurricanes will come. And so will emerging infections, and pandemics. The timing and nature of the next pandemic is always uncertain. But its inevitability is not.

Conspiracy theories: Is the SARS-CoV-2 virus escaped from a laboratory, or even a race-specific bioweapon?

Before I talk about the most plausible origin of SARS-CoV-2, I'd like to discuss conspiracy theories that do *not* explain where the virus came from.

A global crisis with chaos, incomplete information, and death is a breeding ground not only for viruses but also for conspiracy theories. An "infodemic" is circulating on the internet and elsewhere that says the COVID-19 coronavirus did NOT emerge naturally from the evolutionary stew of a Wuhan wet market, but rather originated in a science lab, as the product of human activity.

From that common ground, the story varies depending on the agenda of the person telling it. The Alex Jones/Natural News conspiracy tribe blames China. Specifically, they point a finger at the Wuhan Institute of Virology, which has one of China's only biosafety level 4 (maximum containment) microbiology research labs. Dueling explanations say SARS-CoV-2 is part of a covert Chinese bioweapons program at the lab, or it's from an accident in a vaccine development experiment. Either way, they say the virus is manmade.

I understand the desire to blame a laboratory. There is comfort in assuming a human person or human institution intentionally created this virus, because it implies control. *Nature doesn't wield power over us! If we can manage our governments and institutions, we can be safe*.

We know the Chinese government initially tried to cover up the disease outbreak. And the location of the BSL-4 lab in the epicenter of the epidemic makes it an easy target; such labs are often viewed with suspicion wherever they are. But the emergence of a new, deadly coronavirus from a Chinese wet market is adequately explained by what we already know about virus evolution. It has happened before, with the original SARS, and public health experts have been warning that it would happen again.

Now that it *has* happened, is there evidence to suggest an alternate explanation? **Is there data to blame the BSL-4 lab?**

Conspiracy-mongers claim such data can be found in the genome sequence of SARS-CoV-2. Based on its genes, SARS-CoV-2 is similar to the original SARS coronavirus but is more closely related to other coronaviruses from bats. (This suggests the two viruses have a common ancestor from which they both evolved.) SARS-CoV-2 has unique sequences in some of its genes. Conspiracy believers cite these "never seen before in nature" sequences as evidence for human tampering, but this is a misinterpretation.

All classes of virus have some genes that are highly conserved, that is, if you look at many different examples, they have much the same sequence in these genes. Such genes generally code for proteins whose job is non-negotiable, and are critical to the virus's survival—like brakes on a car. Other genes are less vital, and can vary a lot from one type of coronavirus to another—options like satellite radio or heated seats. Therefore the virus can tolerate a lot of mutations in these genes. **Mutations occur in nature all the time, at random.** They are the raw material of evolution. Their existence is not proof of human intervention. It's proof of Darwin's theory.

Another claim is based on sequence similarity (*homology*) between SARS-CoV-2 and other viruses. For example, a piece of SARS-CoV-2 matches a tiny piece of HIV (human immunodeficiency virus, which causes AIDS). Surely, say the conspiracy fans, this means a human intentionally spliced HIV genes into the coronavirus. No, it does not, because the sequence in question is common and can be found in other coronaviruses from bats—not just in HIV.

In addition, **viruses can shuffle segments of their genomes with each other in the wild, rather like cards in a deck**. This is mostly likely to happen when different species of animal hosts are put close together—such as in the Wuhan market. So even if an emerging virus carries an entire gene from another virus, this would not be proof of laboratory intervention. Influenza is notorious for this kind of wholesale genetic mixing in the wild; it's what triggered flu pandemics in 1957 and 1968.

And yet...

Conspiracy believers do have some facts on their side.

First, **the Chinese government is clearly willing and able to execute a massive coverup**. If there really was an accident at the BSL-4 laboratory in Wuhan, Beijing would do whatever it takes to keep it secret.

Second, this wouldn't be the first time that **an illegal bioweapon escaped and caused a deadly outbreak**, one that was denied and classified.

In 1979 in the USSR, an anthrax outbreak struck the city of Sverdlovsk (now Yekaterinberg). At least 64 people died of an infection the Soviet authorities blamed on consumption of anthrax-contaminated meat. The truth was kept hidden until 1992, shortly after the fall of the Soviet Union. In a brief period of openness during the early Yeltsin years, a team of American biological warfare experts (lead by husband and wife Jeanne Guillemin and Matthew Meselson of Harvard) traveled to Russia to investigate.

Using detailed sleuthing techniques involving door-to-door interviews and meteorology, the team realized that animal and human cases mapped to a narrow zone extending from a military facility on the edge of the city—a zone that matched the direction of the prevailing wind shortly before the outbreak. The team published their conclusion in the prestigious journal *Science*: "the escape of an aerosol of anthrax pathogen at the military facility caused the outbreak."

(Guillemin also wrote a marvelous, accessible book-length description of the mystery called *Anthrax: The investigation of a deadly outbreak*.)

So I acknowledge that the Wuhan Institute of Virology could be doing bioweapons research, and that such a lab could accidentally release a deadly virus like SARS-CoV-2. **Possibility is not proof**. At this time, I have not heard any evidence this is what actually happened.

Other conspiracies:

Professional meddlers in Russian state media are pushing all kinds of theories to blame America for the coronavirus. Different outlets have picked different culprits; they've learned this is the best way to sow suspicion and fear, because it's easier to discredit a single narrative than many different ones.

How about blaming the messenger? Bill Gates is deeply involved in global health and infectious disease. Therefore he, like many other well-informed people, anticipated that the world is at risk for a flu or coronavirus-like pandemic. And he spoke about it in a recent Netflix documentary. Hey, coincidence? Or did BILL GATES ACTUALLY DO IT? Well, you can guess what they're saying in some corners of the internet. Of course any time there's an infectious disease outbreak, somebody blames big pharma, or the health care industry, or another corporate interest as having intentionally caused the outbreak in order to make money.

My take: Haters gonna hate. Your Microsoft operating system might suck but rich people aren't trying to kill you. And even if they were, there are easier and more effective ways. Claims like these demand impressive evidence to back them up. There isn't any.

Is SARS-CoV-2 a race-based bioweapon?

Here's the conspiracy theory of greatest interest to me. Because the first 2000+ victims of COVID-19 were all Chinese people, some are claiming that SARS-CoV-2 is a genocidal, race-based virus that's an intentional product of a secret (and illegal) American bioweapons program designed to take down China.

My take: The title of my third novel, THE HAN AGENT, refers to exactly this kind of biological agent, so I have spent much effort studying the scientific plausibility of a race-based bioweapon. In my thriller, an ultranationalist Japanese cabal tries to finish what Unit 731 of the Japanese Imperial Army started in China in the 1930s. They modify a bird flu virus to target ethnic Han Chinese.

Is SARS-CoV-2 a real-life example of what I imagined?

Obviously not, because the virus has now infected people from every continent, and non-Chinese people are dying. But **is such a genocidal bioweapon theoretically possible?**

A race-based bioweapon would overcome one of the fundamental problems with biological warfare: How do you hurt your enemy without harming your own people? Once an infectious agent is released, it is by definition, infectious. To prevent your germ from attacking you, you need a treatment, a drug, or a vaccine that your enemy does not have. If your people were naturally resistant to the agent, that would be much better.

Thanks to genome science and gene editing techniques, **engineering a virus to selectively kill a particular person** or ethnic group is theoretically possible. Assassinating an individual would be easier

than trying to target an entire group. A November 2012 article in *The Atlantic* by Andrew Hessel, Marc Goodman, and Steven Kotler called "Hacking the President's DNA" explores this possibility in depth.

Creating a genocidal virus that specifically harms one national group but not members of another would be much harder. In order to target a particular ethnicity, members of that group would all have to share a unique genetic feature that could be exploited by the weaponized virus. Such a feature is unlikely to exist, and even if it did, **it's unlikely the feature would be limited to one group.** Humans have interbred so widely that although ethnic groups may be enriched for particular DNA markers, such markers are typically neither universal nor unique to that group. A bioweapon based on such a genetic marker would kill members of out-groups as well, making it no more useful than any other bioweapon.

What is a coronavirus / what is this coronavirus (SARS-CoV-2)?

Coronaviruses are a family of microscopic agents that are shaped like tiny balls covered with round spikes. In an electron micrograph, they look a bit like they're wearing a crown (*corona* means garland or crown). We've known about coronaviruses for a while but didn't care much because they seemed to only cause a mild version of the common cold.

Then in 2002, a cluster of serious lung infections appeared in China. Called severe acute respiratory syndrome (SARS), this mysterious and deadly disease was caused by a new coronavirus. The new virus likely came from exotic civet cats at a Chinese live animal market, and proved to be contagious. It could spread from person-to-person, albeit not very efficiently. Eventually 8,096 people were considered infected, and 774 died, a fatality rate roughly around 10%.

Thanks to the relatively low infectivity of the virus, an effective global health response, and some unexplained good luck, the SARS virus disappeared as suddenly as it had burst on the scene—totally gone by June 2004.

A second coronavirus jumped species into humans in 2012 in Saudi Arabia, giving the name Middle East Respiratory Syndrome coronavirus (MERS-CoV). The original infection source is camels, but most human cases resulted from human-to-human transmission, not from exposure to camels. MERS-CoV is less contagious than SARS-CoV, but more deadly: as of 2016, 1733 cases, 628 deaths (36% fatality rate).

In the last weeks of the decade, in another Chinese exotic animal market, another coronavirus made the leap. In late December 2019, Wuhan ophthalmologist Li Wenliang warned his colleagues to wear protective clothing, because he'd noticed seven cases of a virus that behaved like SARS. The Chinese authorities threatened and silenced Dr. Li. The explosive spread of the virus soon vindicated him, but it destroyed him as well. Dr. Li died of the infection in early February. He's considered a kind of whistleblower martyr for free speech in China.

What is COVID-19 (the disease)? How bad is it?

The official name of the virus is SARS-CoV-2, and the disease it causes is called COVID-19 (coronavirus disease 2019). Like other coronaviruses, SARS-CoV-2 infects epithelial (surface) cells of the respiratory tract. Unlike less-dangerous cold viruses that stick to the upper airways, SARS-CoV-2 enters deep into the lungs. Patients can develop a fever, cough, and aches, and progress to full-blown pneumonia with shortness of breath and cloudy lungs on xray.

In some cases, the patient's first symptoms are not related to the lungs—nausea, diarrhea, vomiting. This makes the outbreak harder to contain. As of now, according to the US Centers for Disease Control (CDC), people become ill between 2 and 14 days after infection.

In good news, it looks like **the vast majority of people who catch SARS-CoV-2 will either have mild illness, or no symptoms at all**. In the best current study cited by the World Health Organization (WHO), of 17,000 cases in China, 82% had mild symptoms, 15% became severely ill, and 3% became "critically" ill. Many, many people might be infected but stay perfectly healthy. This is great for personal health but bad news for public health. Our best weapon in this war is to isolate people with the virus. If those people can't be identified, they will unwittingly expand the epidemic.

The fatality rate is hard to pin down, because it depends on the total number of cases, including mild or invisible ones. We simply don't have that information. On-the-record current estimate is about 2-3% mortality but if undiagnosed, asymptomatic or mild cases were all counted the mortality would be lower. (That rate of mortality is about ten to twenty times higher than seasonal influenza.) As of today, the WHO reports about 82,000 cases and about 2800 deaths.

Of course local conditions affect the death rate, which is higher in China than other countries (so far). China's severe air pollution may have made people in Hubei province more susceptible to pneumonia. Access to good supportive medical care will increase survival.

Why a "new" virus?

Viruses are the simplest of all living things. In fact they're so simple, in some ways they do not even meet the definition of being alive. They cannot reproduce on their own. A virus must enter (infect) a living cell, and then use the host cell as a factory to manufacture more viruses.

Cells don't leave their doors open to viruses. Every species of potential host, and even various cell types within a single host, have unique locks made of surface proteins. **In order to get inside, a virus must pick the lock**. This is why you don't catch calicivirus from your cat when it has a cold, or parvovirus from your dog. Those viruses have "keys" that fit the "locks" on cells in your pet. They don't have the tools to enter human cells.

But sometimes there is overlap, and a virus can infect more than one species. For example, West Nile virus infects both horses and humans; influenza A can infect pigs and birds.

And once in a while, something changes, and a virus that previously couldn't get inside a human cell suddenly can.

There are basically two ways this can happen. **The virus can change,** acquiring the genetic knowledge needed to get through a locked human door. This knowledge can come at random from mutation followed by natural selection, or it can come from genetic exchange with another virus.

The other way is **the virus's circumstances change**. If snow leopards don't eat raccoons, it's not because they don't know how. It's because the two organisms never come in contact. Same with some viruses.

Human behavior, therefore, can give viruses an opportunity to jump species by bringing humans and the virus together in new ways. Building human settlements in virgin rainforest is an example. Or

concentrating an unnatural range of wildlife into a Chinese market, and sending aerosols of animal feces and freshly slaughtered animal tissue directly into the lungs of other animals, human vendors, and shoppers.

An infection that starts in animals and then jumps to humans is called a *zoonosis*. The animal source of SARS-CoV-2 is not yet known. MERS (Middle East Respiratory Syndrome) coronavirus comes from camels. Sometimes more than one animal species acts as an intermediary. The natural reservoir of the original SARS coronavirus is probably horseshoe bats. It arrived in humans by way of an exotic mammalian species called civet cats. In my novel REVERSION, a rabies-like virus travels from bats to humans to chimpanzees, then back to humans.

It's a mystery whether SARS-CoV-2 mutated recently and "learned" how to infect people, or whether this virus already had the power and was waiting for the opportunity to encounter a human lung cell. Either way, in late 2019 in central China, this animal coronavirus jumped into humans.

Why should I be concerned about an emerging infection (new viral disease)?

Public health scientists all over the world worry about *emerging infections*. The World Health Organization and others put a lot of effort into monitoring to try to detect any new infectious diseases as early as possible. (As we've seen with the Wuhan coronavirus, the sooner you start to take actions to contain an outbreak, the better.)

Why should we pay attention to emerging infections like COVID-19 disease? Are they necessarily dangerous?

To some extent, yes, **they are a greater threat, because our bodies have never encountered this enemy before**.

The human immune system is a complex web of cells and biochemical signals that is quite effective at destroying viruses, while doing minimal collateral damage to the body itself. In order to pull off this trick of distinguishing between what is self and what is foreign in the body, the immune system is constantly learning to recognize things that shouldn't be there. When it identifies an invader, it devises a specific strategy to attack and destroy that particular agent.

In the future, if the invader strikes again, the immune system remembers and responds swiftly. This process is what we call *immunization*, and it's the reason you won't get chicken pox twice in your life. It's a process we've learned to use therapeutically, with vaccines.

If humans have not encountered a virus before, then no one has any immunity against it. Nada. Zip. An emerging infection can blaze through a *naïve population* like Panzer tanks on a blitzkrieg, encountering no resistance until people's immune systems have time to respond. Eventually, as people are exposed to the virus and develop immunity, the rate at which the virus is able to spread will slow down. An equilibrium is reached between new cases, and *herd immunity*: the resistance of the population acting like a firebreak to contagion.

In the early days of an emerging pandemic, over 7 billion humans are a gigantic naïve population with no immunity against the virus.

On top of this lack of herd immunity, we have no vaccine against new viruses, and probably no treatment. If an existing drug happens to work against an emerging infection, we don't know which one to use until it's been tested against the new virus.

For these reasons, a new virus like SARS-CoV-2 is inherently more dangerous now than it might be a few years in the future. (An exception would be if the virus mutates and becomes more deadly over time. This is rare.)

HIV, hantavirus, and Ebola are examples of emerging viruses that jumped species from an animal host into humans because of some combination of random mutation and opportunity. The most impressive example is the mother of all modern pandemics, the 1918 "Spanish" flu.

Genetic analysis of old tissue samples containing the deadly pandemic flu virus suggest it originated in some kind of bird species. The virus was so much different from the usual flu everyone had been exposed to previously, that it was essentially a brand-new, emerging infection. The human population was immunologically naïve. There was no vaccine. It's estimated that one in every three people on earth became infected, and more than 50 million people died before the disease disappeared as suddenly as it had arrived.

The other reason to worry about a new virus is our ignorance. We don't have the information we need to properly assess the risk. How deadly is the new virus? How easily, and by what means, does it spread from person to person? How can you tell if someone is infected? Can a person with no symptoms still be contagious? How long does it take to get sick after you're first exposed?

These critical questions tell us how bad things are likely to get. They help us weigh the urgency of our response. With a new infection, there's really only one thing we can do: try to contain it. As we're seeing right now with the extreme measures the Chinese government and others are taking to restrict people to their homes, and to isolate anyone who may have been exposed, public health actions have a cost. Should we lock down entire cities and paralyze the economy to halt an emerging infection? Well, that depends on how dangerous the new virus is. And in the early months of an outbreak, we simply don't have the answers.

Will COVID-19 become a pandemic?

I wrote this section in mid-February 2020. I predicted that yes, SARS-CoV-2 would go global for the reasons outlined below. A few short weeks later, the pandemic is here. So you might want to skip ahead to the next section.

A pandemic is a global epidemic. A pandemic of SARS-CoV-2 would mean outbreak clusters like the one in Wuhan in cities all over the world. Those disease clusters might not be as bad as Wuhan, or they could be worse. The draconian efforts at isolation in the Chinese city, even if they work, are too authoritarian to be copied in many other countries.

It all comes down to the infectivity of the virus. Epidemiologists put a number on how easily a disease-causing agent is spread: it's called the basic reproduction number, or R_0 (r-naught). R_0 is the average number of healthy people who will catch the virus from each infected person. A lot of factors influence R_0, and its value can change. If R_0 is less than one, a disease is disappearing. If R_0 is greater than one, then an outbreak is expanding.

At the time I'm writing this, best estimates of R_0 for SARS-CoV-2 are in the range of 3. If there are large numbers of people who get infected but don't get sick or show any symptoms that would bring them in for testing, then the number is even higher.

Epidemiologists are working furiously to get good data to generate accurate answers to this and other key questions. But it will take time. Meanwhile, we have anecdotes and incidents that hint at the magnitude of the risk.

In the city of Wuhan, the official tally of cases is a massive undercount.

- Day after day in January and February, the number of patients testing positive for the coronavirus was limited by the number of tests they were able to do.
- Many patients who clearly were suffering from a respiratory infection tested negative once or even twice before getting a positive test for the virus
- Because the hospital system was overwhelmed, and because movement within the city had been restricted, many patients stayed home and out of the official count
- Based on screening of foreigners who were evacuated from Wuhan, it's possible that the number of silent infections, in people who don't show any symptoms, may be as high as ten times the official case count.

The Diamond Princess proves SARS-CoV-2 is very contagious

- Because coronavirus was on board, this cruise ship was held in quarantine in Japan for two weeks with about 3700 people on board (passengers and crew). Of those people, 691 tested positive for the virus. That's almost 20% of everybody on board, in a situation where best effort was being made to minimize contact and exposures.

Not only the aged and infirm are dying

- Pneumonias are usually most lethal for people who are not in the best of health to begin with. For example, last year in the US, 75% of deaths from influenza were in people over the age of 65. COVID-19 is also most deadly for the elderly but young people are dying too. Li Wenliang, the Chinese ophthalmologist who was the first to alert fellow physicians about a new SARS-like pneumonia cluster in late December 2019, was only 33 years old when he died six weeks later. Is his case unusual? We'll see.
- This is important because the 1918 pandemic flu broke the rule, killing mostly people in the prime of life. We believe the reason is their own immune systems responded so vigorously that it damaged their lungs. This phenomenon of an almost-suicidal effort by our immune system to save us is called a *cytokine storm*. If SARS-CoV-2 triggers a cytokine storm, then fatalities will skew toward younger, healthier people rather than just the old and infirm.

SARS-CoV-2 spreads like the flu

- Influenza virus (the flu) spreads through respiratory droplets produced when someone coughs or sneezes. You can also catch it from other exposures to saliva, on surfaces or hands. Apparently SARS-CoV-2 is similar.

People can carry and spread SARS-CoV-2 without knowing they're infected.

- The existence of asymptomatic carriers makes it more likely COVID-19 will go global. We don't yet know how long the asymptomatic period is, but it could be as long as two weeks. This is worrisome.

Also, some patients present with gastrointestinal symptoms like diarrhea and nausea instead of cough and fever. Because they don't look like they have COVID-19, they might have more opportunity to spread the infection.

With these conditions, community spread is inevitable.

What will a SARS-CoV-2 pandemic be like?

Let's put it this way. Life in China's Hubei province (where the city of Wuhan is) since the COVID-19 outbreak took off in early January has been difficult: quarantines, travel restrictions, lack of access to health care, sickness, fear. There have been almost 3,000 deaths so far.

Now consider life in the United States at the same time. Since September, a deadly respiratory virus that spreads the same way as SARS-CoV-2 has stalked the country, and has caused about 16,000 deaths. **Yet hardly anyone is concerned,** there are no travel restrictions, and in fact many people have refused to get a vaccine that could protect them from this threat.

What's up with that?

You've probably guessed that the American virus is influenza, or flu. Flu is contagious. Flu kills people. But flu is familiar. We know what to expect from the seasonal flu that strikes every winter. Our hospitals and clinics are prepared. And there's a vaccine. So despite the large number of deaths, life goes on as usual for most of us.

My point is, **the disruption of a pandemic will depend in part on how we choose to respond. It's not all about the disease itself**. A viral pandemic in 2009 caused more than 200,000 deaths worldwide in the first twelve months. Public interest, and public disruption, was far less than with SARS-CoV-2. Bet you can't even name the virus (flu again—it was H1N1 influenza).

With this coronavirus, however, the high level of concern is justified because of all the unknowns. We don't have a solid read on the mortality rate of COVID-19 but it's clearly lower than the original SARS, and lower than MERS. Rabies, Ebola, HIV, H5N1 influenza, smallpox are all far more lethal than the Wuhan coronavirus. I believe the mortality rate will ultimately turn out to be lower than current estimates of about 2%, simply because I believe a huge number of mild or asymptomatic infections are being missed.

Case-fatality rates below 1%, or even below 0.1% (the approximate lethality of seasonal flu), **can still generate a lot of deaths, however, if the agent is highly contagious and a large number of people are infected**.

Efforts to break the chain of transmission are likely to cause hardship for many more people than the virus itself. In the city of Wuhan, for example, 11 million people went on lockdown but only about 65,000 have (officially) gotten sick from the virus. Keep this in mind when you prepare. Cancelled bus routes, or cancelled travel plans, or your kid's school closing, or your employer cutting your hours are problems that will affect almost everyone. Pneumonia will not.

Medical impacts

Even if COVID-19 ends up not being as deadly as it seems now, if the virus is highly contagious, health care systems could be overwhelmed by the sheer number of cases. We've seen this in Wuhan. To some

extent hospitals deal with this during flu season every year, but with an emerging virus the problem can be much worse. With no existing immunity in the community, many more patients end up needing medical help. So **even if you and your family do not catch the virus** (which is **statistically most likely**, by the way), a coronavirus pandemic could impact your health. **Getting care for ordinary medical problems will become difficult** if the system is grappling with large numbers of COVID-19 patients.

American hospitals are some of the world's best. The sophistication and intensity of care they can provide are at the highest level—that is, on a normal day. **Most hospitals run at or near full on a regular basis**. Economically, this makes sense. Empty beds are like empty seats on an airplane; they're lost revenue. Nobody intentionally builds a hospital twice as big as the community needs. Therefore *surge capacity* is lacking. If an emerging virus arrives in town and sends a bunch of people to the emergency room, hospitals have nowhere to put them.

Not only hospitals will be affected. You might have trouble getting into a clinic, and you don't want to sit in a waiting room full of people who might have the coronavirus. Same goes for pharmacies. They might be unable to serve everyone, and you don't want to go there anyway. There could also be shortages of some drugs, partly from increased demand, partly from a disruption of the global supply chain. **Plan ahead and keep two or three months of any essential medications in reserve**.

Timeline

Most cold and flu viruses are seasonal. We don't yet know whether SARS-CoV-2 will follow this pattern. **If cases fall off in spring or summer, be wary for the virus to return in the fall**. The most devastating pandemic of modern times—the 1918 "Spanish" flu—came in three waves. The first wave of infections appeared in the spring of 1918. Lots of people got sick, but death rates were not terribly high. Things quieted down in the summer. Then the second wave hit between September and November. For unknown reasons, this second round of pneumonias was far more deadly. (A third wave of influenza fatalities afflicted many countries in early 1919.) This epidemiologic pattern was unique, and contemporary scientists have not been able to fully explain it. We know so little about SARS-CoV-2 that we can't predict how it will play out over the next one to two years.

Another important unknown about this virus: Does infection confer immunity? In other words, **if you catch COVID-19 once, are you then protected from re-infection in the future?** Is a mild or asymptomatic case enough to confer immunity? This matters for the individual, and for the population. For individuals, this is particularly important for health care workers. In a pandemic, caregivers can be in short supply because they're either sick, or avoiding contact with the sick. People who have recovered and are immune can be valuable for providing care to those who are infected. For the population as a whole, herd immunity will slow or stop the spread of the infection. If many people are mildly infected and gain immunity to reinfection, this will greatly help to arrest the pandemic. The opposite is also true.

Vaccine development

Vaccines are the best way to stop a pandemic but currently no vaccine exists for SARS-CoV-2. Vaccines are *specific*. They trigger an immune response against one virus, so existing vaccines such as the flu vaccine will not protect against SARS-CoV-2. However the technology to design and manufacture the flu vaccine might be used to create a vaccine against the COVID-19 coronavirus.

The majority of "flu shots" are produced by a method that is slow, reasonably effective, and inexpensive to do on a large scale, which is important because nearly a *billion* doses of the seasonal flu vaccine are needed every year.

The process begins with an educated guess. Experts try to predict which strains of influenza A and B will circulate in the coming flu season (generally October to April in North America). The major *antigens* (immunologic markers) for those flu viruses are cloned into a laboratory flu strain that can be grown in chicken eggs. When the best strain is ready, the CDC or another affiliate of the WHO Global Influenza Surveillance and Response System gives the vaccine strain to private manufacturers for mass production. The modified flu virus is injected into fertilized chicken eggs. The virus proliferates in the chicken embryos. Later, virus is harvested from the eggs, purified, and inactivated (killed). The dead virus is standardized for dose, and used as an injectable vaccine.

This is why they ask you if you're allergic to eggs before giving you a flu shot. There can be trace amounts of egg protein in a flu vaccine produced this way.

This method of vaccine production won't work for coronavirus. But new experimental techniques might.

Some flu vaccines *can* be given to people with egg allergies. These egg-free vaccines start the same way—with a prediction of which antigens to use, and cloning the genes for those antigens into a harmless laboratory virus. But instead of using chicken eggs to grow the virus, the manufacturer uses tissue culture, great tanks of cells that serve as host for the recombinant virus. The U.S. Department of Health and Human Services is right now working with Sanofi Pasteur, a vaccine maker, to use this cell culture technology to rapidly create a coronavirus vaccine candidate.

Other vaccine companies are pushing the boundaries even further. San Diego-based Inovio Pharmaceuticals is trying to dispense with the recombinant virus, and instead clone coronavirus genes into bacteria. The advantage is bacteria can grow on their own; you don't need to also grow a bunch of cells in tissue culture for them to infect. The gamble is to guess which coronavirus genes might actually work as a vaccine. Not every part of a virus will stimulate a good immune response.

Or how about getting rid of *all* the middlemen? That's the goal of DNA and RNA vaccines. In this approach to vaccination, rather than injecting a killed virus or an antigenic part of a virus, DNA or RNA coding for a bit of viral protein is given. These genetic instructions tell the recipient's cells how to make antigens from the virus inside their own body. DNA vaccines have been used in veterinary medicine for years. Scientists in the private sector and at the US National Institute of Allergy and Infectious Diseases are working on RNA-based vaccines for coronaviruses.

Practical information

How does SARS-CoV-2 virus spread?

The most important question about an emerging virus was answered early in this outbreak: Can the virus spread from one person to another? The answer is yes. SARS-CoV-2 is capable of human-to-human transmission. And unlike Ebola or HIV, it appears to do so fairly easily, in much the same way that the common cold or flu does.

Based on what we know about other coronaviruses, we expect **the primary way the Wuhan agent spreads is in close contact (closer than about six feet) by means of respiratory droplets** that a person expels into the air when they cough or sneeze, or possibly talk. Technically this is different from a virus that spreads through the air directly. For coronaviruses, probably the droplets are necessary. When a virus-laden droplet gets into a person's mouth or nose, infection may ensue.

There's a good chance that this coronavirus, like many other respiratory viruses, **can be deposited on a surface and survive for days**. If someone touches the contaminated surface and then their eyes, nose, or mouth, they can be infected. Influenza virus, for example, can linger on a surface for up to two days. One coronavirus that has been studied (not SARS-CoV-2) remained infectious for up to nine days, depending on the material, the humidity, and the temperature. (Dry, warm air reduces the persistence of the virus.)

What should I do?

The time to prepare for a pandemic (or any disaster, for that matter) is before it happens.

Things you can do to prepare for a coronavirus pandemic

1. Get a flu shot

The influenza vaccine (flu shot) does not give you immunity to SARS-CoV-2. So why did I put this at the top of my list?

If an emerging virus causes a pandemic, flu will still be here. More than ever, you would NOT want to catch it. Flu patients with pneumonia will have to compete with COVID-19 patients for limited medical resources. There are only so many hospital beds, and so many respirators, to go around. In a pandemic situation, your flu symptoms could be treated as symptoms of COVID-19. You might be quarantined, or treated, with patients who carry the SARS-CoV-2 virus. Then you could end up infected with both viruses!

Improve your overall risk profile. Get the shot.

2. Optimize your health

As I described earlier, in a pandemic we'll experience general dysfunction of the health care system. People seeking help with ordinary medical problems may find access is difficult. If you have a chronic medical condition, do what you can now to get your situation in order. To the extent possible, learn how to monitor and manage your condition. Try to anticipate what you might need. On that note,

3. Have several months' supply of all your medications on hand

Some drugs might be in short supply during a pandemic. You won't want to walk into a pharmacy and be exposed to a lot of sick people. And you might be sick yourself. If you regularly use a medicine, stock up on 1-3 months' worth.

4. Stock up on pantry groceries and pet supplies

One good thing about preparing for a pandemic compared to a hurricane or flood natural disaster is you shouldn't have to worry about losing your utilities. The lights and water should stay on. But there are lots of reasons why you might not be able to go shopping. You might be sick. You might be caring for a sick

family member. There might be a quarantine in effect. You might want to avoid public places. Therefore it's wise to have a supply of non-perishable food in your pantry. Enough for two weeks is a good start. Don't forget your pets. Have several weeks of their food or medicine at hand, too.

5. Buy rubbing alcohol (isopropyl alcohol) or bleach

You can catch a coronavirus by touching a contaminated surface and then touching your face. Protect your home or the area where you work by disinfecting surfaces that you touch frequently. Soap and water are an excellent choice, as are many regular household cleansers. For some surfaces, this isn't convenient. Studies have shown that the original SARS-CoV and MERS coronaviruses can be mostly inactivated on a surface with either rubbing alcohol or bleach, with a contact time of one minute or more. Alcohol you should use straight from the bottle (typically sold at 70% or 91% concentration; either is fine). Household bleach from your laundry should be diluted 1:50.

6. Buy surgical masks

I hesitate to make this recommendation because it's so widely misunderstood, and masks are in short supply in many places already. You shouldn't wear a regular surgical mask to protect yourself if you are healthy. You wear a mask *to protect others from you* if you are sick. SARS-CoV-2 is spread by the tiny droplets that come from your mouth when you cough or sneeze. A mask can trap some of those. (It's useless against a truly airborne infection, which SARS-CoV-2 is not.) In a pandemic situation, **you should wear a mask if you have a cough**. Your greatest need for masks will be if a family member gets sick and you are caring for them at home. Putting a mask on the patient will help to protect everyone else in the household.

7. Know a recipe for oral rehydration solution

In a pandemic, you might find yourself caring for a sick family member—or yourself—at home. There is no treatment for COVID-19 except general supportive care. One part of that is keeping the patient hydrated and fed. Some patients with SARS-CoV-2 experience diarrhea. If that happens, you should know how to prepare an oral rehydration solution at home. It's a simple solution of water, sugar and salt that is better absorbed from the intestines than plain water or sugary liquid like juice or soda. The universal recipe is below. Other variants based on Gatorade G2, chicken broth, tomato juice, or cranberry juice can be found here.

Oral Rehydration Solution

1 quart water

1/2 teaspoon salt

2 Tablespoons sugar

8. Make a plan

If you're a parent, make a plan for what to do if your child's school or daycare is closed. At your place of work, make a plan for how you will cope if other employees are absent, or for the myriad ways your business might be affected.

Once SARS-CoV-2 is circulating in your community, you'll want to be armed with the following information.

Things to avoid to protect yourself from coronavirus infection

Don't panic.

Remember, even in a pandemic, the odds are in your favor that you will stay healthy. Also keep in mind that the biggest impacts won't be from the virus itself, but from the public response to the virus.

Avoid travel.

Use common sense. If there's an active outbreak in an area, don't go there unless you have to. On the other hand, see #1.

Avoid sick people

Stay away from hospitals, clinics, and pharmacies if you can.

Avoid gatherings.

Avoid unnecessary antibiotics.

Antibiotics are life-saving drugs, but they are overprescribed and overused. When you take antibiotics, you kill off not only the harmful bacteria in your body but also many of the varied, helpful bacteria that live inside you. In the beautiful balance of a healthy body, those resident bacteria (collectively called the *microbiome*) protect you from infections by crowding out disease-causing invaders. There is also some evidence that your normal bacteria help to regulate the immune response to influenza virus infection of the lungs. While no one has studied this question with SARS-CoV-2, it would be prudent to protect your microbiome and only take antibiotics if they are clearly necessary. And remember that antibiotics do not work against viruses such as the common cold.

Things to do to protect yourself from coronavirus infection

Wash your hands. A lot.

Other than getting sneezed or coughed on by an infected person, the most likely way you might pick up the virus is by touching your face with a contaminated hand. We all touch our faces more frequently than we think, and you don't know when you've touched a contaminated surface. Washing with soap and water will clean the virus off your hands, if you do it thoroughly. The CDC recommends that you wet your hands with water; apply soap; lather up, including the backs of your hands, between your fingers, and under your nails; then scrub for at least 20 seconds before rinsing.

If you don't have access to soap and water, the next best option is to use an alcohol-based hand sanitizer.

Stop shaking hands.

Find ways to touch fewer things and fewer people. Instead of shaking hands in greeting, bow or do an elbow bump. Press elevator buttons with your elbow instead of a finger. Practice touching your face less.

Practice "social distancing"

Maintain a six-foot distance from anyone who is sick, coughing or sneezing to avoid respiratory droplets. If you are caring for someone and will be in closer contact, if possible put a mask on your patient.

Clean frequently touched surfaces and objects in your home or workplace.

Desks, doorknobs, railings, keyboards, phones, toys—all are surfaces where coronavirus can linger. Soap and water or regular household cleansers are a good choice. If you prefer, alcohol or bleach diluted 1 to 50 are also effective sanitizers.

TAKE CARE OF YOUR HEALTH.

Get enough sleep. Eat a healthy diet. Exercise. A healthy body will be better able to fight the infection if you're exposed.

Finally, if a pandemic comes to your town, we each have a responsibility to one another. Here are some of the recommendations from above with a different spin. The CDC calls them "nonpharmaceutical interventions."

Ways you can protect others from coronavirus infection during an outbreak

STAY HOME WHEN YOU'RE SICK

STAY HOME IF YOU HAVE BEEN EXPOSED TO SOMEONE WHO IS SICK

PRACTICE GOOD COUGH (AND SNEEZE) ETIQUETTE

The main way SARS-CoV-2 spreads is by respiratory droplets expelled when someone coughs or sneezes. So cover your nose and mouth with a tissue when you cough or sneeze. If you don't have a tissue, use your clothes. Throw away the used tissue in a covered container if possible, and then wash your hands.

WASH YOUR HANDS. A LOT.

IF YOU ARE SICK AND ENCOUNTERING OTHER PEOPLE, WEAR A FACEMASK, OR COVER YOUR NOSE AND MOUTH WITH A CLOTH.

Conclusion

The situation with SARS-CoV-2 and the pneumonia it causes, COVID-19, is rapidly evolving. For the moment, the information in this ebook is accurate. I will try to keep it up to date.

Follow my blog at AmyRogers.com for the latest.

If you like my science writing, you might enjoy my collection of articles about how science and engineering are behind the scenes of much that we take for granted in daily life. The book is called SCIENCE IN THE NEIGHBORHOOD and it's suitable for all ages.

If you enjoy a page-turning thriller novel with real science, please try one of my microbiology-themed titles. To entice you, I've included links to excerpts of each.

You are welcome to contact me at Amy@AmyRogers.com

About the Author

Amy Rogers, MD, PhD, is a Harvard-educated scientist, novelist, journalist, educator, critic, and publisher who specializes in all things science-y. Her novels use real science and medicine to create plausible, frightening scenarios in the style of Michael Crichton. Formerly a microbiology professor, she is the founder of ScienceThrillers Media and runs the ScienceThrillers.com book review website. Learn more at AmyRogers.com

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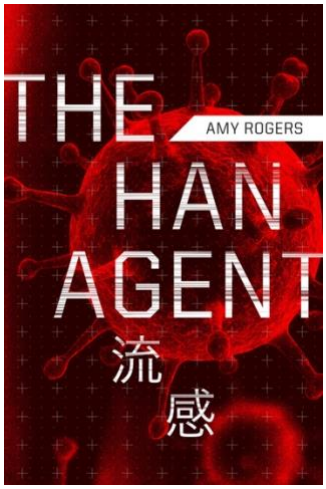
Books by Amy Rogers



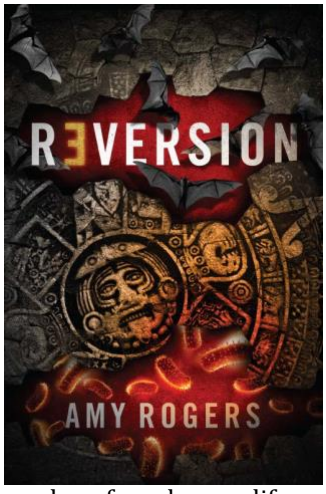
In the 1930s, Japanese scientists committed heinous crimes in their quest for the ultimate biological weapon.

The war ended. Their mission did not.

Eighty years later, Japanese-American scientist Amika Nakamura won't let rules stand between her and scientific glory. When the ambitious young virologist defies a ban on the genetic manipulation of influenza, she's expelled from the university. Desperate to save her career, she accepts a position with a pharmaceutical company in Tokyo. Soon after, a visit to a disputed island entangles her in a high-profile geopolitical struggle between Japan and China. Applying her singular expertise with bird flu in a risky experiment may be the only way out. Little does she know that Japanese ultranationalists and a legacy of unpunished war crimes lurk in the shadows, manipulating people, politics, and science.

But DNA doesn't lie. Amika uncovers a shocking truth: a deadly virus is about to put the "gene" in genocide.

CLICK TO READ AN EXCERPT OR LEARN MORE ABOUT THE HAN AGENT



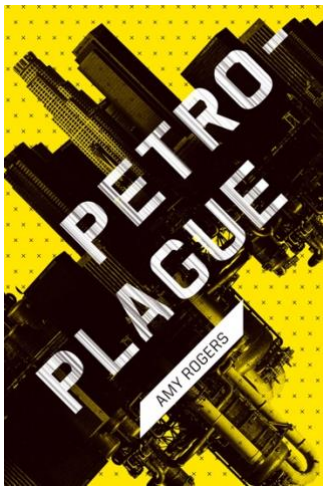
Rabies kills. Can it also cure?

Tessa Price, PhD, knows what it's like to lose a child to a genetic disease. To spare another mother this pain, she invents a radical new gene therapy that might save the life of seven-year-old Gunnar Sigrunsson. Unable to get regulatory approval to treat Gunnar in the US, she takes her clinical trial to the Palacio Centro Medico, a resort-like hospital on a Mexican peninsula where rich medical tourists get experimental treatments that aren't available anywhere else.

When the hospital is taken over by a brutal drug cartel, Tessa goes into hiding with a remarkable trio of Palacio clients—rich Texan Lyle Simmons, his much-younger Brazilian girlfriend, and his protection dog, a German shepherd named Dixie, only to learn that the gangsters aren't the only deadly threat they face. A rabies-like infection that began in the Palacio's research chimpanzees has spread to humans. Tessa investigates and finds a shocking connection to her gene therapy experiment. In the wake of this discovery, Tessa must weigh the value of one human life against another—including her own.

In REVERSION, Amy Rogers pits cutting-edge biotechnology against the power of nature and asks, can a virus ever be truly tamed?

CLICK TO LEARN MORE OR READ AN EXCERPT OF REVERSION



What if bacteria turned all the gasoline in Los Angeles turned into vinegar?

Carmageddon doesn't begin to describe it.

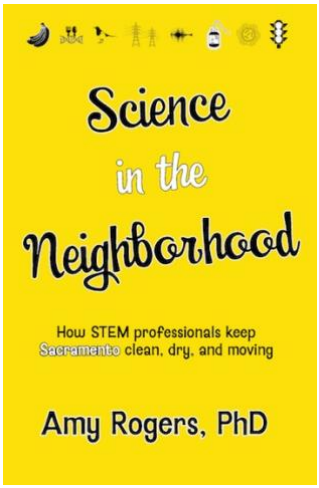
PETROPLAGUE does.

UCLA graduate student Christina Gonzalez wanted to use biotechnology to free America from its dependence on Middle Eastern oil. Instead, an act of eco-terrorism unleashes her genetically modified bacteria into the fuel supply of Los Angeles, turning gasoline into vinegar.

With the city paralyzed and slipping toward anarchy, Christina must find a way to rein in the microscopic monster she created. But not everyone wants to cure the petroplague—and some will do whatever it takes to spread it.

From the La Brea Tar Pits to university laboratories to the wilds of the Angeles National Forest, Christina and her cousin River struggle against enemies seen and unseen to stop the infection before it's too late.

CLICK TO LEARN MORE OR READ AN EXCERPT OF PETROPLAGUE



Science behind the scenes of everyday life in Sacramento

In this fascinating collection, Dr. Amy Rogers holds her nose at a landfill, pets a snake, listens to an iron lung, votes for a science idol, watches fish climb a ladder, buys earthquake insurance, visits a water treatment plant, and much more as she explores the science and engineering behind Sacramento transportation, weather, utilities, ecology, and health. Whether you live in Northern California or not, you'll find answers to questions you took for granted, and practical tips that you can use at home—because science is in everybody's neighborhood.

Where does my garbage go? Why does the price of gasoline go up in late spring? What causes the Delta breeze? Who keeps local mosquito populations in check? What is a vernal pool? Where does my tap water come from? How does Sacramento stay dry during flood season? When should I use a defibrillator? Why is it so hard to roast a turkey? After I flush, what happens?

With index.

CLICK TO LEARN MORE OR READ AN EXCERPT OF SCIENCE IN THE NEIGHBORHOOD