Paranoid by Design

FORM FOLLOWS FUNCTION AT AMERICA'S NEW INFECTIOUS DISEASE RESEARCH LABORATORY, WHERE SCIENTISTS WILL STUDY THE SECRETS OF THE WORLD'S DEADLIEST PATHOGENS.

THE INTEGRATED RESEARCH FACILITY at Fort Detrick, Md., doesn't look menacing. The three-story glass-and-brick structure, which could fit seamlessly into any suburban office park, is typical of buildings designed by architects who read studies linking sunlight with worker productivity. The leather chairs in the atrium seem to encourage lounging. The National Institute of Allergy and Infectious Diseases, which operates the IRF, plans to install a coffee bar in the atrium.

But cocooned within the nearly completed $105 million facility is a laboratory built like a submarine—11,125 square feet of airtight, carefully pressurized space. As soon as next spring, 30 doctorate-level scientists wearing protective suits and hoods will conduct groundbreaking research in these rooms, trying to determine how lethal infectious diseases kill their hosts.

Hemorrhagic fevers like Marburg and Ebola, which are caused by viruses, are among the world's most horrific afflictions. For about seven days after infection, patients suffer from flulike symptoms, but as the virus multiplies, blood starts to seep from the skin,

by Joe Pappalardo *photographs by Noah Sheldon*

A biohazard suit protects Peter Jahrling, chief virus hunter at the Integrated Research Facility in Fort Detrick, Md. *Opposite:* The air-lock entrance to the lab's hot zone.

mouth, eyes and ears. Internal organs hemorrhage into bloody, shapeless masses. Some of these fevers kill up to 90 percent of those who contract them, and they can be passed along by close contact with bodily fluids, maybe even by a sneeze.

Scientists still don't know much about how these rare but deadly diseases operate. If they take root in America—carried by unsuspecting travelers or by terrorists—the medical community would have no vaccines to halt their spread. And there are only a handful of laboratories in the world equipped to experiment with these highly communicable pathogens; none has the sophisticated diagnostic gear that is being installed at the IRF. Lessons learned here could one day mean the difference between an outbreak and an epidemic.

The best time for an outsider to visit the IRF is before it goes hot—that is, now, before the deadly bugs are brought to the site. "It's the *only* time," says Jason Paragas, the facility's associate director for science. Paragas is one of the 30 staffers who will work in the highly restricted lab. Quietly friendly, with a stout frame and easy disposition, he talks and moves with deliberation and does not seem to have an impulsive bone in his body. His dress is tidy and Maryland casual—loose button-down shirts, but never a tie. The 37-year-old researcher has spent nearly three years working on the new facility, so he makes a highly informed tour guide.

Paragas is standing in what will be the dividing line between two labs—an outer lab rated to handle dangerous infectious diseases and an inner lab designed for the worst pathogens in the world. The outer area is the medical research equivalent of a maximum-security prison—Biosafety Level 3. The inner sanctum is supermax, or BSL-4. Researchers can study bubonic plague at level 3; Ebola and other killers that are transmissible and currently incurable must be quarantined at level 4. The institute is so security-conscious that it asked POPULAR MECHANICS not to identify the floor on which the BSL-3 and BSL-4 labs are located.

To enter the restricted BSL-4 lab, Paragas first has to pass through two stainless-steel doors set up as an air lock. He punches in a code that deactivates the magnetic lock on the first door. The keypad also alerts the building automation system (BAS) that the air pressure is about to change. The BAS adjusts the airflow, increasing the pressure in the BSL-3 area and decreasing it in the air lock. Once Paragas is ready to enter BSL-4, the BAS will ensure that high-pressure air in the air lock flows into the low-pressure, high-security lab, trapping airborne pathogens. The deeper the level of containment, the lower the pressure. "Biocontainment sucks," Paragas says. "Any breach is sucked in by the negativity."

The air-lock door closes with the sound of an overworked drill, which is caused by the rapid inflation of a rubber bladder that seals the smooth edges of the door. Once the facility is operational, the air lock will also serve as a decontamination shower. For 7 minutes, vertical banks of nozzles will spray water and virus-killing chemicals over exiting scientists' hoods and suits before the door to BSL-3 will open.

Paragas sees the glow of a green light: The BAS is allowing him to push open the second door and enter BSL-4. Fluorescent lights, hanging in airtight boxes to prevent microorganisms from collecting on edges, reflect off easy-to-decontaminate stainless steel. The walls have a glistening sheen from the layers of epoxy potting compound that form a continuous seal across every surface. Light fixtures and electrical outlets that penetrate the seal are housed in airtight boxes and lathered in epoxy. Construction workers went so far as to strip insulation from the ends of wires that emerge from the walls and seal the tips with the compound.

The IRF's architects designed everything inside BSL-4 to this level of security. Even fire-sprinkler heads are fitted with valves to prevent viruses from making an unlikely swim up the pipes. At the conclusion of experiments, lab technicians will rinse metal equipment with chemicals and then further purify the gear with an autoclave bake. "We are in control of our agents at all times," Paragas says.

Fresh air: A labyrinth of ducts guides air in the lab through banks of powerful filters, each of which removes more than 99 percent of particles larger than 0.0003 mm. Staff say air leaves the building cleaner than it arrives.

Clean water: Water and decontamination chemicals from sinks and showers collect in three 1500-gallon tanks in the facility. These tanks heat waste fluids to 250 F, killing anything that survives the disinfectant rinse.

Good views: Staff will slide infected monkeys into the tube of this X-ray machine, the first to be adapted for use in high biocontainment. Scanners move around the tube for 360-degree views of the progress of a disease.

Once the BSL-4 lab goes hot, the animal testing will begin. Since primates react to diseases in ways similar to humans, they are the subjects for many level-4 experiments. The IRF staff is acutely aware of the sensitivity of using monkeys in medical research, but note that the threat posed by potential plagues demands real-world study. IRF staff say they handle the animals with the care they would provide human patients. "We liken this to a monkey intensive-care unit," says Peter Jahrling, the IRF's director.

Jahrling has spent more than three decades studying infectious diseases, yet he admits that the way they work remains a mystery. "The animals die of multisystem failure," Jahrling says, "but what initiates the terminal events?" To answer that question, researchers here will rely on medical scanners housed in four adjacent rooms in the BSL-4 bubble. No other biocontainment facility employs this type of equipment.

Each machine generates different information—a positron emission tomography (PET) scanner measures tissue and organ damage, while a magnetic resonance (MR) instrument is used to discern details about the vascular system. The X-ray machine will identify abnormalities in the chest and lungs; CT scans will show whether there is swelling in the brain. Snapshot by snapshot, the combination can reveal how hemorrhagic fevers like Ebola dismantle a healthy body.

Engineers at Philips Medical Systems modified the four scanners for use in this BSL-4 facility by moving the bulk of the hard-to-seal electronics outside the hot sections of the lab for maintenance. They also installed laser and infrared tripwires that will automatically halt moving parts on the scanners before they make contact with barriers between the level 4 hot zone and the outside world. Architects designed the rooms around the scanners: Copper sheets in the floor of the MR room, for example, shield the machine from radio-frequency interference. These powerful medical devices present their own dangers, such as the radioactive materials used in the PET scanner and MR magnets strong enough to pull rings off fingers or metallic replacement hips out of joints. "In here," Paragas says, "there are hazards heaped on hazards."

To gather data on the stages of an infectious disease, scientists in other labs typically expose a number of animals to the same pathogen and then kill the subjects at intervals, examining the corpses to chart the disease's progress. But thanks to the scanners, IRF staff will follow the course of a disease in a single animal, requiring fewer to be sacrificed. Data from an individual primate patient is also more consistent.

The IRF's initial tests will allow diseases to rage unchecked through their animal hosts. Researchers will wheel caged monkeys from holding areas into the hot sections of the lab where they will inject them with highly concentrated viral doses. After allowing about a week for the viruses to take hold, handlers will sedate the monkeys and place them in the tubes of the imagers. Technicians outside the BSL-4 area will operate the scanners remotely, rotating them around a tube to peer through skin and bone to measure where oxygen and blood flows are failing, which will indicate what organs the viruses are attacking—and in what order. "Now we are shining a flashlight on the subjects to find the viruses," Paragas says. "By using these scanners, we'll be able to illuminate the whole body. There will be nowhere for the viruses to hide."

Once base-line knowledge of a disease's progress has been established, scientists will test the animals' reaction to drugs, vaccines and therapies. Researchers want to identify infectious diseases that run a similar course, so that the same vaccines and treatments can be applied to numerous outbreaks. "We can't afford to make a vaccine for every emerging disease," Jahrling says.

The first rule in any fight is to know the enemy—and that places this outwardly normal office building on the front line of a war against invisible foes that can mutate into more powerful strains. Jahrling, one of the nation's most seasoned virus hunters, has no illusions as to which organisms have the upper hand: "The bugs are always one step ahead." **PM**