

Dan Rather Reports

Episode Number: 805

Episode Title: Cutting Edge

Description: Synthetic biology is at the forefront of modern science, as researchers reinvent cells by manipulating DNA to solve some of the most important problems facing the world.

ACT 1: TEASE

DAN RATHER (VOICE OVER)

TONIGHT... THE CUTTING EDGE. MANIPULATING THE BUILDING BLOCKS OF LIFE TO MAKE THE THINGS OUR CIVILIZATION NEEDS...

JAY KEASLING,
CEO, JBEI

You don't want to be harvesting the entire rainforest in order to get a small quantity of a great anti-cancer drug. You'd like to take a little piece of that tree, find the genes in there, put them into a microbe and get that drug out. That's the promise of synthetic biology...

RATHER (ON CAMERA)

AND... YOUNG MINDS RUSH INTO A NEW SCIENTIFIC FIELD... THAT COULD BE THE BIGGEST REVOLUTION SINCE THE DAWN OF THE COMPUTER AGE...

DREW ENDY,
ASSISTANT PROFESSOR OF BIOENGINEERING, STANFORD UNIVERSITY

The agenda is a century long agenda. 10, 20, 30, 40, 70, 100 years. That's the way we're thinking about it.

RATHER (ON CAMERA)

BUT COULD THIS NEW SCIENCE BE USED FOR HARM... LIKE CREATING A DEADLY NEW VIRUS? THE FBI SAYS IT'S ON THE CASE.

ED YOU,
SUPERVISORY SPECIAL AGENT, FBI

This field is moving so rapidly, the barrier to entry to be able to do something like that scenario-- is getting lower and lower.

RATHER (VOICE OVER)

WE'LL BRING YOU THE NEWS TONIGHT ON DAN RATHER REPORTS.

ACT 2: THE SYN BIO REVOLUTION

DAN RATHER (ON CAMERA)

GOOD EVENING... TEN YEARS AGO THIS APRIL, THE LANDMARK SCIENTIFIC EFFORT KNOWN AS THE HUMAN GENOME PROJECT CAME TO AN END. IT TOOK MORE THAN A DECADE TO PIECE TOGETHER THE DNA SEQUENCE OF A SINGLE HUMAN BEING... AND THE FINAL PRICE TAG WAS NEARLY 3 BILLION DOLLARS.

TONIGHT'S PROGRAM IS A CHANCE TO SEE HOW FAR THE SCIENCE OF LIFE HAS COME SINCE THEN. AND THE ANSWER IS: A REMARKABLY LONG WAY.

RATHER (VOICE OVER)

IT WOULDN'T BE SURPRISING IF A LOT OF WHAT YOU KNOW ABOUT GENETICS COMES FROM HOLLYWOOD FANTASIES LIKE JURASSIC PARK...

JURASSIC PARK (1993)

A DNA strand, like me... is a blueprint for building a living thing

RATHER (VOICE OVER)

IN COUNTLESS MOVIES AND TV SHOWS, DNA PLAYS A STARRING ROLE... THE HI-TECH SLEUTHS OF CSI USE IT TO SOLVE CRIMES...

CSI: CRIME SCENE INVESTIGATION (2000)

For a conviction, we're gonna need a DNA sample.

RATHER (VOICE OVER)

AND IN THE DIMLY LIT LABS OF SCIENCE FICTION FILMS...

SPLICE (2009)

What's the profile?

RATHER (VOICE OVER)

DNA IS THE PLOT DEVICE THAT LETS PEOPLE PLAY GOD.

SPLICE (2009)

Our lab has combined the DNA from a variety of species to create a completely new life form.

RATHER (VOICE OVER)

IN MOVIES LIKE THIS ONE, CALLED "SPLICE," THE POSSIBILITIES OF GENETICS ARE LIMITED ONLY BY THE DIRECTOR'S IMAGINATION.

RATHER (VOICE OVER)

BUT WHILE WE'VE BEEN CAUGHT UP IN THE FANTASY ON SCREEN... A REAL-LIFE SCIENTIFIC REVOLUTION HAS BEEN UNFOLDING ALL AROUND US.

WITH MACHINES LIKE THIS ONE, GENETICS HAS ENTERED THE AGE OF MASS PRODUCTION... AND SCIENTISTS ARE MANIPULATING THE BUILDING BLOCKS OF LIFE LIKE NEVER BEFORE. AS THESE ROBOTIC ARMS AND WHIZZING CONVEYORS DO THEIR TIRELESS WORK, THEY'RE GIVING RISE TO A BRAND NEW SCIENTIFIC FIELD. IT'S CALLED SYNTHETIC BIOLOGY... AND IT'S ALREADY HELPING US SOLVE PROBLEMS FAR MORE PRESSING THAN BRINGING DINOSAURS BACK TO LIFE.

WHAT IF YOU COULD CREATE A MICROORGANISM THAT CLEANS UP POLLUTION? OR A NEW KIND OF ALGAE THAT PRODUCES JET FUEL? WHAT IF YOU COULD PROGRAM CELLS TO FIGHT DISEASES? SYNTHETIC BIOLOGISTS ARE PREDICTING ALL OF THIS AND MORE... AND SOME OF IT IS ALREADY POSSIBLE. IT'S ALL THANKS TO THAT VITAL MOLECULE... DNA.

THE THREAD OF LIFE (1960)

This model represents only a short piece of a DNA molecule, magnified many times.

RATHER (VOICE OVER)

IT WAS ONLY SIX DECADES AGO THAT SCIENTISTS DISCOVERED THE STRUCTURE OF DNA... RECENT HISTORY WHEN THIS EDUCATIONAL FILM WAS MADE IN 1960. YOU PROBABLY RECOGNIZE THE FAMOUS DOUBLE-HELIX... WINDING AROUND LIKE A TINY SPIRAL STAIRCASE.

EACH STEP OF THAT STAIRCASE IS MADE FROM ONE OF FOUR DIFFERENT CHEMICAL BUILDING BLOCKS...

THE THREAD OF LIFE (1960)

1, 2, 3, 4.

RATHER (VOICE OVER)

COMMONLY KNOWN BY THEIR INITIALS: A, T, C, AND G.

THE THREAD OF LIFE (1960)

Could the sequence of the stair steps be a kind of message to the cell, a genetic code telling it what to do?

RATHER (VOICE OVER)

BACK THEN, SCIENTISTS WERE JUST BEGINNING TO APPRECIATE THE TREMENDOUS SIGNIFICANCE OF THOSE FOUR LETTERS.

THE THREAD OF LIFE (1960)

So it may be the arrangement of the steps in this fantastic stairway that spells out the difference between you and me, between a fish and a bird, between a grasshopper and a redwood tree.

RATHER (VOICE OVER)

HALF A CENTURY LATER, THE SCIENCE HAS COME FURTHER THAN ITS PIONEERS COULD HAVE IMAGINED. THAT FOUR-LETTER ALPHABET OF A, T, C, AND G—FAR FROM BEING A MYSTERY—IS NOW SOMETHING WE CAN ACTUALLY WRITE OURSELVES.

JEREMY MINSHULL, CEO OF DNA 2.0

So these are our oligonucleotide synthesizers.

RATHER (VOICE OVER)

JEREMY MINSHULL IS THE CEO OF DNA 2.0. LOCATED NEAR SAN FRANCISCO, THEY ARE IN THE BUSINESS OF SELLING MADE-TO-ORDER DNA. SCIENTISTS AND RESEARCHERS FROM AROUND THE WORLD CAN SIMPLY SEND IN THE GENETIC SEQUENCE THEY WANT, BY EMAIL.

MINSHULL

That information is pulled into these machines and tells these machines what order of A's, C's, G's, and T's to chemically attach.

RATHER (VOICE OVER)

THE MACHINE IS A BIT LIKE THE PRINTER THAT MIGHT BE SITTING ON YOUR DESK...
BUT INSTEAD OF CARTRIDGES OF INK, IT HAS BOTTLES OF THOSE FOUR DNA BUILDING
BLOCKS.

MINSHULL

And so these bottles here are the nucleotides, there's T, A, C, and G.

RATHER (VOICE OVER)

IT'S THE FIRST STEP IN A GENETIC ASSEMBLY LINE...

MINSHULL

So when this is done...

RATHER (VOICE OVER)

WHERE DNA FRAGMENTS GO FROM ONE MACHINE TO THE NEXT...

MINSHULL

And those get loaded onto this robot...

RATHER (VOICE OVER)

ALL OF IT METICULOUSLY TRACKED WITH BARCODES AND COMPUTERS.

MINSHULL

Can I borrow one of these...

RATHER (VOICE OVER)

THE END RESULT IS THIS TINY VIAL...

MINSHULL

This now is DNA.

RATHER (VOICE OVER)

CONTAINING A MINUTE AMOUNT OF CUSTOM DNA. THE SHIPPING DEPARTMENT POPS THE VIAL INTO AN ENVELOPE, AND OFF IT GOES VIA FEDEX.

FOR THE STAFF OF DNA 2.0, IT'S JUST ANOTHER DAY AT THE OFFICE. BUT THERE'S SOMETHING PROFOUND GOING ON HERE. THEY ARE MANUFACTURING SOMETHING THAT, UNTIL RECENTLY, COULD ONLY BE MADE BY MOTHER NATURE.

AND WITH THIS TECHNOLOGY, THERE'S NO REASON YOU CAN'T PRINT SEQUENCES OF A'S, T'S, C'S, AND G'S THAT HAVE NEVER EXISTED BEFORE IN THE HISTORY OF LIFE ON EARTH.

MINSHULL

Evolution has been doing billions of years worth of experiments. But evolution has not been tasked with achieving the same goals that we want to achieve. And so we look to evolution to give us starting points. But those are not necessarily the endpoints that we want.

RATHER (VOICE OVER)

AND THAT'S OPENING THE DOOR TO SOME INCREDIBLE POSSIBILITIES...

JAY KEASLING,
CEO, JBEI

Once we've engineered the microbes, we put them in the freezer here...

RATHER (VOICE OVER)

JAY KEASLING IS A PROFESSOR OF BIO-ENGINEERING AT THE UNIVERSITY OF CALIFORNIA BERKELEY, AND THE HEAD OF BIOSCIENCES AT LAWRENCE BERKELEY NATIONAL LAB. HE'S THE MAN BEHIND SYNTHETIC BIOLOGY'S FIRST BIG SUCCESS STORY... A NEW WAY TO CREATE LIFE-SAVING DRUGS.

KEASLING

When I started my own research laboratory, I started with the idea that we could engineer microbes as factories for chemicals.

RATHER (VOICE OVER)

MICROBES NORMALLY PRODUCE THE CHEMICALS THEY NEED FOR THEIR OWN SURVIVAL... THINGS LIKE FATTY ACIDS AND PROTEINS. THE INSTRUCTIONS FOR HOW TO BUILD THOSE CHEMICALS ARE WRITTEN IN DNA CODE, AND KEASLING THOUGHT

THAT BY RE-WRITING THAT CODE... HE COULD GET THE MICROBES TO MAKE WHAT HE WANTED INSTEAD.

JACK NEWMAN WAS A RESEARCHER IN KEASLING'S LAB.

JACK NEWMAN,
CHIEF SCIENCE OFFICER, AMYRIS

Every biological entity has a program that it's running. You know, it's running the yeast program, which says, "Be a yeast," that means you need to take in sugar, you need to spit out ethanol, you need to make some fats for your membranes, you need to make X, Y, and Z and it's a program. So what synthetic biology allows you to do is say: here's the molecule I want to make. Now I can program yeast to make that rather than settle for whatever it happens to make out of the box.

RATHER (VOICE OVER)

THE ONLY QUESTION WAS: WHAT TO MAKE FIRST?

KEASLING

And then one of my students found a paper on this drug called Artemisinin. And we looked at the structure and thought, "Gosh, we ought to be able to produce that."

RATHER (VOICE OVER)

ARTEMISININ IS ONE OF THE ONLY EFFECTIVE TREATMENTS FOR MALARIA... A DISEASE THAT KILLS MORE THAN HALF A MILLION PEOPLE EVERY YEAR.

THE DRUG COMES FROM A PLANT GROWN IN PARTS OF ASIA AND AFRICA. PRODUCTION IS TIME CONSUMING AND EXPENSIVE... AND THE SUPPLY CAN BE UNRELIABLE. BUT WHAT IF YOU COULD GET IT ANOTHER WAY... NO FARMING NECESSARY?

NEWMAN

We said, you know what, we can program these little creatures called yeast that many people use to make beer and wine., to make, very efficiently antimalarial drugs at low cost, and enough to cure everyone who has malaria.

RATHER (VOICE OVER)

KEASLING AND HIS TEAM FIRST DELVED INTO THE PLANT'S DNA... TO UNDERSTAND HOW IT MAKES ARTEMISININ. THEN THEY RE-CREATED THAT PROCESS INSIDE A YEAST CELL, STRINGING TOGETHER A COMPLEX SERIES OF GENETIC INSTRUCTIONS TO MAKE

THE ORGANISM PRODUCE THE DRUG... A MOLECULE IT HAD NEVER PRODUCED BEFORE.

IT WAS PERHAPS THE MOST COMPLEX FEAT OF GENETIC ENGINEERING EVER ACCOMPLISHED... AND WHEN SYNTHETIC ARTEMISININ HITS THE MARKET LATER THIS YEAR, IT WILL BE A MAJOR STEP IN THE FIGHT AGAINST MALARIA. BUT FAR MORE THAN THAT, IT REPRESENTS A COMPLETELY NEW WAY FOR OUR CIVILIZATION TO GET THE THINGS IT NEEDS...

KEASLING

You don't want to be harvesting the entire rainforest in order to get a small quantity of a great anticancer drug. You'd like to take a little piece of that tree that does it, find the genes in there, put them into a microbe and brew that just like you're brewing beer. And get that drug out. That's the promise of synthetic biology...

RATHER (VOICE OVER)

...AND DRUGS ARE JUST THE TIP OF THE ICEBERG.

ALREADY, THE CHEMICAL GIANT DUPONT IS USING BACTERIA TO PRODUCE PLASTICS... AND GOODYEAR IS REPROGRAMMING MICROBES TO MAKE RUBBER, FOR TIRES. THERE ARE START-UP COMPANIES GOING AFTER THINGS LIKE SPICES, COSMETICS, AND INDUSTRIAL LUBRICANTS. AND EVERYONE FROM EXXON MOBIL TO THE U-S GOVERNMENT IS BETTING THAT SYNTHETIC BIOLOGY HOLDS THE KEY TO MAKING CLEAN, RENEWABLE FUEL.

ALL TOLD, SYNTHETIC BIOLOGY MAY BE POISED TO UPEND MULTIPLE BILLION DOLLAR INDUSTRIES, FROM ENERGY TO MANUFACTURING. THE MOST FAR-REACHING POSSIBILITIES ARE STILL DECADES OFF.....BUT ALL ACROSS THE COUNTRY, AN ENTIRE GENERATION OF NEW SCIENTISTS IS BEING TRAINED TO MAKE THOSE DREAMS A REALITY.

STANFORD UNIVERSITY STUDENTS

This class kind of like teaches us the tools to do it, like the basic tools and then just lets us free to experiment on our own.

RATHER (VOICE OVER)

THESE SOPHOMORES AT STANFORD UNIVERSITY ARE TAKING A CLASS CALLED FUNDAMENTALS FOR ENGINEERING BIOLOGY... IT'S A CRASH COURSE IN HOW TO DESIGN YOUR OWN MICRO-ORGANISM. JUST 19 AND 20 YEARS OLD, THEY'RE DOING

THINGS IN THIS LAB THAT, NOT LONG AGO, WOULD HAVE BEEN IMPOSSIBLE FOR EVEN THE MOST ACCOMPLISHED SCIENTISTS.

THE STUDENTS ARE BEING TAUGHT TO DESIGN BIOLOGY IN MUCH THE WAY AN ARCHITECT DESIGNS A BUILDING... THEY SKETCH OUT SEQUENCES OF A's, T's, C's, AND G's ON A COMPUTER... AND SEND THEM OUT FOR THE DNA TO BE PRINTED.

BIOENGINEERING STUDENT #1

We use a program called Gene Designer, from DNA 2.0. It's a super user friendly software.

BIOENGINEERING STUDENT #2

Just looking here we can imagine what's going to happen on the molecular level inside the cell.

RATHER (VOICE OVER)

AS SYNTHETIC BIOLOGY HEATS UP, IT'S ATTRACTING THE KINDS OF BRIGHT MINDS THAT A DECADE AGO WOULD HAVE GONE INTO COMPUTER PROGRAMMING OR ENGINEERING. AND THAT INCLUDES DREW ENDY, THE PROFESSOR WHO TEACHES THIS CLASS.

DREW ENDY,
ASSISTANT PROFESSOR OF BIOENGINEERING, STANFORD

I took several years of biology in HS. Problem I ran into was every now and then we had an exam where we're supposed to memorize, for example, the Latin species names of 200 insects. Oh, I hated that. So I would fail that test.

RATHER (VOICE OVER)

ENDY IS ONE OF THE PIONEERS OF SYNTHETIC BIOLOGY... BUT IN COLLEGE, HE ACTUALLY MAJORED IN CIVIL ENGINEERING. HE DIDN'T WANT A CAREER SPENT LOOKING THROUGH A MICROSCOPE... HE WANTED TO BUILD THINGS.

ENDY

And that's what I learned how to do. Reinforce concrete, surveying, steel, water supply, sewage treatment.

RATHER (VOICE OVER)

THAT IS, UNTIL HE STARTED TO REALIZE THAT BIOLOGY COULD BE USED TO BUILD THINGS, TOO. AFTER ALL... IT ALREADY BUILDS EVERYTHING FROM THE FEATHERS OF

A BIRD... TO CORAL REEFS IN THE OCEAN. ALL LIVING MATTER IS—IN A SENSE—
MANUFACTURED... THROUGH BIOLOGY.

ENDY

The more I thought about this, the more excited I became to partner with biology and recognize it as the most advanced manufacturing platform on planet earth. We're not very good at making things with biology right now, we could get a lot better, so let's go.

RATHER (VOICE OVER)

STANFORD IS PLACING A BIG BET ON SYNTHETIC BIOLOGY... TO SHOW US JUST HOW BIG, ENDY TOOK US OUT TO A BALCONY OVERLOOKING A MASSIVE CONSTRUCTION PROJECT... A BUILDING THAT WILL HOUSE STANFORD'S NEWEST DEPARTMENT, CALLED BIO-ENGINEERING.

ENDY

It's a five story building that cost about a quarter of a billion dollars. We've got design studios, as if you were an architect, but instead of working with buildings you're working with biology. We've got wet laboratories, we've got a machine shop.

Starting a new department at Stanford doesn't happen very often. The last time Stanford started a department, it was called computer science.

RATHER (VOICE OVER)

WITH THAT DEPARTMENT, STANFORD HELPED LAUNCH THE REVOLUTION THAT GAVE THIS PART OF CALIFORNIA A NEW NAME—SILICON VALLEY. SCORES OF TECHNOLOGY TITANS GOT THEIR START HERE, AND WENT ON TO BUILD A NEW ECONOMY WORTH TRILLIONS. NOW, THE UNIVERSITY IS THROWING ITS WEIGHT BEHIND WHAT IT HOPES WILL BE ANOTHER WORLD-CHANGING — AND FORTUNE-MAKING — INDUSTRY.

ENDY

The agenda is a century long agenda: 10, 20, 30, 40, 70, 100 years. That's the way we're thinking about it.

RATHER (VOICE OVER)

AND WITH SO MUCH LEFT TO BE DONE, EVEN THESE SOPHOMORES CAN BREAK NEW GROUND, WITH PROJECTS THAT TAKE ON MAJOR ISSUES. ONE GROUP IS GOING AFTER POLLUTION, TRYING TO CREATE A SINGLE-CELLED ORGANISM THAT WOULD EAT MERCURY CONTAMINATION. IF IT WORKS, IT WOULD BE A SORT OF LIVING WATER FILTER.

BIOENGINEERING STUDENT #1

It's actually really surprising that we were able to make this in just five or six weeks. It's exciting actually because no one's really done it before.

BIOENGINEERING STUDENT #1

Literally at the end of all this, you just have 2500 letters.

ENDY

We teach them how to put that DNA into an organism in a safe way. And see whether or not their designs work. Most of the time they don't work. But a couples times each class, they get something that works. That's really exciting for everybody.

RATHER (VOICE OVER)

IN OTHER WORDS, IT'S STILL A MATTER OF TRIAL AND ERROR... BUT THAT'S HOW SCIENTIFIC REVOLUTIONS ARE BUILT... ONE EXPERIMENT AT A TIME. AND WHEN THIS REVOLUTION IS FINISHED, THERE'S NO TELLING WHAT WILL BE POSSIBLE.

ENDY

It feels like there's a lot of work to do. It feels like most things haven't yet been dreamt about, let alone made true. And so it's a humbling feeling.

ACT 3: BIOFUELS

DAN RATHER (VOICE OVER)

IF SYNTHETIC BIOLOGY IS GOING TO CHANGE THE WORLD OVER THE NEXT CENTURY... IT WON'T HAPPEN WITHOUT THE BRILLIANT YOUNG MINDS IN THIS CROWD. THIS IS I-GEM—THE INTERNATIONAL GENETICALLY ENGINEERED MACHINE COMPETITION.

IGEM PARTICIPANT

So our project dealt with operational coupling. We used it as a tool to evaluate the transition...

RATHER (VOICE OVER)

HELD EVERY YEAR ON THE CAMPUS OF THE PRESTIGIOUS MASSACHUSETTS INSTITUTE OF TECHNOLOGY, I-GEM MAY BE THE BEST PLACE IN THE WORLD TO SEE THIS SCIENTIFIC REVOLUTION IN PROGRESS.

IGEM PARTICIPANT #2

It needed to be well quantified so that we can predict risk and of course it needs to be harmless for the environment.

RATHER (VOICE OVER)

FOR ASPIRING BIO-ENGINEERS, I-GEM IS THE OLYMPICS. TO EARN A SPOT HERE, TEAMS OF COLLEGE STUDENTS FROM AROUND THE GLOBE SPEND MONTHS HUNKERED IN THEIR LABS, REPROGRAMMING THE GENETIC CODE INSIDE CELLS.

IGEM PARTICIPANT #3

Producing cells and implanting them directly into the affected tissue...

RATHER (VOICE OVER)

THEN THEY GO HEAD-TO-HEAD TO SEE WHO HAS DESIGNED THE MOST INNOVATIVE AND USEFUL NEW ORGANISMS.

IGEM PARTICIPANT

This is a protein construct; it is a two domain system.

RATHER (VOICE OVER)

THE FIRST I-GEM WAS FIVE TEAMS COMPETING IN A SINGLE CLASSROOM. JUST EIGHT YEARS LATER, THERE ARE MORE THAN 200 TEAMS, AND THEY'VE OUTGROWN EVEN MIT'S LARGEST AUDITORIUM.

AND WHAT ARE THESE YOUNG GENETIC ARCHITECTS TRYING TO PULL OFF? THINGS THAT SOUND MORE LIKE CUTTING EDGE RESEARCH THAN UNDERGRADUATE SCIENCE EXPERIMENTS...

UVA STUDENT

You then put the ATG gene onto the viral genome in a place where it going to be transcribed.

RATHER (VOICE OVER)

THIS YEAR, STUDENTS FROM THE UNIVERSITY OF VIRGINIA CONCEIVED A NEW WAY TO TEST FOR DEADLY DISEASES...

UTAH STATE PUT SPIDER DNA INTO BACTERIA TO PRODUCE SUPER-STRONG SILK...

[Groningen practicing]

GRONINGEN STUDENT

So you know for sure the bacterium is healthy and it works.

RATHER (VOICE OVER)

AND THE WINNING TEAM, FROM THE NETHERLANDS, ENGINEERED A MICROBE THAT CAN DETECT SPOILED MEAT...

BUT THERE'S A REASON YOU'RE NOT LIKELY TO SEE THESE IDEAS OUTSIDE OF A LAB ANY TIME SOON. THE STUDENTS' PRESENTATIONS USUALLY COME... WITH SOME CAVEATS... WRINKLES THEY'RE STILL TRYING TO IRON OUT. IT CAN BE A LONG WAY BETWEEN AN EXCITING PROOF OF CONCEPT... AND A REAL-WORLD PRODUCT.

ALL AROUND THE WORLD RIGHT NOW, SCIENTISTS AND ENTREPRENEURS ARE FACING THIS SAME CHALLENGE, AS THEY STRUGGLE TO MAKE THE PROMISE OF SYNTHETIC BIOLOGY A REALITY. AND A LOT OF PEOPLE ARE COUNTING ON THEM TO SUCCEED INCLUDING THE U.S. GOVERNMENT.

THE OBAMA ADMINISTRATION BELIEVES THAT SYNTHETIC BIOLOGY IS BRINGING US "CLOSER TO THE THRESHOLD OF A PREVIOUSLY UNIMAGINABLE FUTURE." THOSE ARE THE WORDS OF A REPORT RELEASED LAST APRIL, CALLED THE NATIONAL BIOECONOMY BLUEPRINT. IN IT, THE ADMINISTRATION LAID OUT A LONG LIST OF AMBITIOUS GOALS FOR THE NEW SCIENCE—FROM CLEANING UP THE ENVIRONMENT TO CREATING NEW INDUSTRIES THAT WILL SUPERCHARGE AMERICA'S ECONOMY.

AND THERE'S PERHAPS NO BETTER EXAMPLE OF THE HIGH HOPES RIDING ON SYNTHETIC BIOLOGY—AND THE OBSTACLES STANDING IN THE WAY—THAN ONE OF THE GOVERNMENT'S OWN SCIENCE PROJECTS... A MASSIVE EFFORT TO TAKE ON CLIMATE CHANGE.

JAY KEASLING,
CEO, JBEI

We're doing basic research for the technologies of the future...

RATHER (VOICE OVER)

REMEMBER JAY KEASLING? HE'S THE SCIENTIST WHO TAUGHT YEAST CELLS TO MAKE AN ANTI-MALARIA DRUG. NOW, HE'S TEACHING THEM TO MAKE SOMETHING OUR CIVILIZATION DEPENDS ON: FUEL.

KEASLING

Here we have this huge problem, climate change, looming, and one of the solutions is to replace our petroleum based fuels with renewable carbon neutral fuels.

RATHER (VOICE OVER)

KEASLING NOW HEADS THE JOINT BIO-ENERGY INSTITUTE—OR JBEI, LOCATED IN EMERYVILLE, CALIFORNIA. JBEI IS THE GOVERNMENT’S MOST AMBITIOUS INVESTMENT IN SYNTHETIC BIOLOGY, WITH 135 MILLION DOLLARS ALREADY SPENT BY THE DEPARTMENT OF ENERGY.

KEASLING

This is where we engineer the microbes that produce the fuels. Doesn't look too different from any other molecular biology lab. We get microbes to grow on plates.

RATHER (VOICE OVER)

BUT UNLIKE TRADITIONAL BIO-FUELS, SUCH AS ETHANOL, THIS IS THE REAL DEAL: SOMETHING SO SIMILAR TO THE GASOLINE AND DIESEL WE ALREADY USE THAT IT CAN GO RIGHT IN THE TANK... NO CHANGES NECESSARY TO EXISTING ENGINES.

KEASLING

The key is that we've got, trillions of dollars of infrastructure that run on hydrocarbon based fuels. So we need fuels that will work with that existing infrastructure.

RATHER (VOICE OVER)

THE PETROLEUM-BASED FUELS THAT CURRENTLY POWER THAT INFRASTRUCTURE PUT NEARLY 2 BILLION TONS OF CARBON INTO THE ATMOSPHERE EVERY YEAR, ALMOST A THIRD OF THE NATION’S TOTAL. JBEI WANTS TO PUT A HUGE DENT IN THAT NUMBER... BY PRODUCING THE GREENEST FUEL THE WORLD HAS EVER SEEN.

IT STARTS WITH SOMETHING THAT’S LITERALLY GREEN: PLANTS. THE MICROBES THAT PRODUCE THE FUEL NEED A SOURCE OF FOOD... AND THIS IS WHAT JBEI HAS IN MIND.

MAKING FUEL FROM PLANTS IS NOTHING NEW. BUT CONVENTIONAL BIOFUELS, USUALLY MADE FROM CORN OR SUGAR CANE, USE THE SAME PARTS OF THE PLANT THAT WE EAT. JBEI WANTS TO USE THE DISCARDED STALKS AND STEMS, AS WELL AS PLANTS LIKE WEEDS AND GRASSES THAT AREN’T NORMALLY USED FOR ANYTHING. THEY HOPE THIS WILL HELP MAKE THE FUEL NOT JUST ECO-FRIENDLY, BUT ALSO INEXPENSIVE.

BUT HOW DO YOU GET MICROBES TO EAT WEEDS? THAT'S WHERE SYNTHETIC BIOLOGY COMES IN.

JBEI IS SOUPING UP ITS MICROBES WITH DNA BORROWED FROM COWS, TERMITES, AND OTHER CREATURES THAT ARE GOOD AT DIGESTING PLANT MATTER. THEY ALSO ADD GENETIC INSTRUCTIONS THAT TELL THE MICROBES HOW TO TRANSFORM THAT BROKEN-DOWN PLANT-MATTER INTO FUEL.

KEASLING

Here on this tray, we've got all these little test tubes, right? You can see that film of stuff there, looks like it's producing some kind of fuel, on the top.

RATHER (VOICE OVER)

THEY'RE LEARNING AS THEY GO, CREATING HUNDREDS AND EVEN THOUSANDS OF DIFFERENT DNA COMBINATIONS TO SEE WHAT WORKS.

KEASLING

In many ways it's the same as breeding dogs. Right? Over centuries we bred dogs for different traits, we're just speeding up that breeding process here. Maybe we can go in and see the tanks.

RATHER (VOICE OVER)

THE ONES THAT DO THE BEST JOB...GRADUATE TO THE NEXT LEVEL...

KEASLING

Maybe we learn that it doesn't scale up very well. So we've gotta go back to the laboratory and do some more tweaks. If it survives this, then we go to the next larger scale...

RATHER (VOICE OVER)

THAT'S DOWNSTAIRS, WHERE THE TANKS RUN AS LARGE AS EIGHTY GALLONS.

AT THE END OF IT ALL, SOMETHING ASTOUNDING: FUEL THAT HAS COME OUT OF A TEST TUBE, NOT OUT OF THE GROUND.

KEASLING

"Where's the tube where the fuel comes out!"

RATHER (VOICE OVER)

AND IT'S IDENTICAL TO WHAT YOU FIND AT THE GAS STATION...

SCIENTIST

This is the one we care about. This is the diesel.

KEASLING

Read the gas handle. We should have a tube with a gas handle on it. We knew you could do this in theory. But actually seeing it happen in practice, seeing those blebs of oil float on to the top there, and that diesel could then be used as is, that's really satisfying.

RATHER (VOICE OVER)

BUT THIS IS WHERE THE MAGIC OF SCIENCE RUNS INTO THE REALITIES OF THE MARKET. RIGHT NOW, THE PROCESS IS TOO EXPENSIVE...

KEASLING

The fundamental issue though with fuels is that they're really cheap. If you think about it, a gallon of fuel is much cheaper than a gallon of bottled water.

RATHER (VOICE OVER)

WHICH MAKES COMPETING WITH THAT PRICE AT THE PUMP A MAJOR CHALLENGE. SO JBEI'S FOCUS NOW IS FINDING WAYS TO MAKE THE PROCESS MORE EFFICIENT.

KEASLING

As you get closer and closer to the goal, it gets harder and harder to get there. So you imagine a sprinter, right? And to get to that world record, once they're really fast, getting beyond that world record is really hard to do. It takes a lot of work.

RATHER (VOICE OVER)

BUT SOME WONDER WHETHER BIOFUELS WILL EVER CROSS THAT FINISH LINE, EVEN IN THE AGE OF SYNTHETIC BIOLOGY. IN RECENT YEARS, A NUMBER OF COMPANIES HAVE TRIED TO USE THE SCIENCE TO MAKE FUELS FOR THE COMMERCIAL MARKET—INCLUDING A VENTURE CALLED AMYRIS, WHICH KEASLING HIMSELF CO-FOUNDED. AT FIRST, THE COMPANY WAS A MEDIA AND WALL STREET DARLING.

WHEN THEY WENT PUBLIC IN 2010, THE SHARE PRICE SOARED, AMID PROMISES THAT THEY WOULD SOON BE PRODUCING MILLIONS OF GALLONS OF BIODIESEL. BUT AMYRIS MISSED THAT TARGET—BADLY... AND HAS SINCE SHIFTED ITS FOCUS TO PRODUCTS OTHER THAN FUEL. SINCE 2011, THE COMPANY'S STOCK HAS LOST ALMOST 90 PERCENT OF ITS VALUE.

OTHER COMPANIES HAVEN'T DONE MUCH BETTER, BUT SYNTHETIC BIOLOGY IS FACING MUCH BIGGER QUESTIONS THAN WHETHER OR NOT IT'S ECONOMICALLY VIABLE. A NUMBER OF CRITICS THINK THE SCIENCE IS MOVING TOO FAST... AND THAT FAR FROM SOLVING OUR PLANET'S PROBLEMS, IT WILL ACTUALLY CREATE NEW ONES.

ERIC HOFFMAN,
FOOD AND TECHNOLOGY POLICY CAMPAIGNER, FRIENDS OF THE EARTH

We think that synthetic biology can certainly bring some promises to society. But at the same time it will bring a large number of risks, and most of those risks haven't been looked at just yet.

RATHER (VOICE OVER)

ERIC HOFFMAN RUNS THE BIOTECHNOLOGY CAMPAIGN FOR FRIENDS OF THE EARTH, AN ENVIRONMENTAL GROUP WITH A LONG HISTORY. THEY GOT THEIR START FIGHTING NUCLEAR POWER... AND NOW THEY SEE SYNTHETIC BIOLOGY IN A SIMILAR LIGHT—AS A CUTTING-EDGE TECHNOLOGY WITH UNACCEPTABLE RISKS.

HOFFMAN

You're talking about hundreds if not thousands and tens of thousands of new genes being created on a computer, put into organisms, and we have no clue how those new genes and traits in those novel organisms will work. We don't know how they'll act in the environment.

RATHER (VOICE OVER)

FRIENDS OF THE EARTH IS JUST ONE OF THE GROUPS CAMPAIGNING AGAINST SYNTHETIC BIOLOGY, WITH CONCERNS RANGING FROM SAFETY TO ITS POTENTIAL IMPACT ON THE ECONOMY. ONE OF THE BIGGEST FEARS IS THAT ENGINEERED MICROBES WILL GET OUT OF THE LAB AND BECOME A NEW KIND OF INVASIVE SPECIES... SOMETHING HOFFMAN THINKS COULD BE DISASTROUS.

HOFFMAN

You can imagine if an algae is engineered to produce oil or petroleum and it escapes into a local river or escapes into a local lake and it survives and it still produces oil. We would have a new source of oil pollution. And these organisms will be forever reproducing in the wild.

KEASLING

I live in this community, the last thing I want to do is pollute this community with genetic pollution or with an organism that would get out and wreak havoc.

RATHER (VOICE OVER)

KEASLING TOLD US THAT THE ORGANISMS AT JBEI, WHICH ARE DESIGNED TO LIVE IN LAB CONDITIONS, WOULD HAVE A HARD TIME SURVIVING IN THE WILD. AND IF THEY DO SURVIVE? HE THINKS MORE SCIENCE IS THE ANSWER.

KEASLING

We're looking at how do you make those organisms even safer? As we start to engineer them, how do we put switches in them so that if they get out of the tank, they don't grow at all, or they self-destruct?

HOFFMAN

They like to say that they'll be able to engineer any risky issues out of their bugs. But unfortunately all that is theoretical. They haven't been able to prove they can do that yet. And yet that's the promise they're selling to the public. That, "Trust us, we know what we're doing. We're going to do it right, because we have good intentions."

RATHER (VOICE OVER)

RATHER THAN HIGH-TECH SOLUTIONS, HOFFMAN WANTS MORE RESEARCH DONE ON THE RISKS... BUT OF THE HUNDREDS OF MILLIONS OF FEDERAL DOLLARS BEING SPENT ON SYNTHETIC BIOLOGY RESEARCH, LITTLE TO NONE IS BEING SPENT ON RISK ASSESSMENT.

AND FRIENDS OF THE EARTH IS ALSO QUESTIONING SOME OF SYNTHETIC BIOLOGY'S SUPPOSED BENEFITS.

HOFFMAN

There's this assumption, if we're using plants to feed our bugs to produce our stuff, then we're automatically green. But unfortunately you have to look at broader implications around land use, water, food.

RATHER (VOICE OVER)

ALREADY, DEMAND FOR TRADITIONAL BIOFUEL CROPS IS DRIVING UP FOOD PRICES AND IN SOME CASES FORCING PEOPLE IN POOR COUNTRIES OFF THEIR LAND. A NUMBER OF ACTIVIST GROUPS PREDICT THAT SYNTHETIC BIOLOGY WILL MAKE THAT

PROBLEM FAR WORSE, AS ENTIRE INDUSTRIES BECOME DEPENDENT ON PLANT-HUNGRY MICROBES. THE QUESTION IS: WHERE IS ALL THAT ADDITIONAL PLANT-MATTER—AND THE LAND TO GROW IT ON—GOING TO COME FROM?

HOFFMAN

Much of that land is needed in order to produce food. Already we are in short supply of agricultural land, water, and fertilizer to produce food for a growing population. And if we're going to switch all that land to produce just biomass to feed synthetic bugs, I think it raises a brand new set of issues.

RATHER (VOICE OVER)

HOFFMAN WANTS TO PUT THE BRAKES ON. LAST YEAR, FRIENDS OF THE EARTH JOINED MORE THAN A HUNDRED ORGANIZATIONS FROM AROUND THE WORLD IN CALLING FOR A MORATORIUM. IT WOULD PROHIBIT THE (QUOTE) “RELEASE AND COMMERCIAL USE OF SYNTHETIC ORGANISMS.”

HOFFMAN

We are not saying that there should never be synthetic biology. We're saying let's do this smart and make sure that we think through all the risks beforehand so we can prevent them, or at least mitigate them as much as we can. Because right now the synthetic biology industry is running full speed ahead.

KEASLING

Some critics would say "Well it's too early to be engineering biology. We don't know enough yet." And I would argue no, we know enough.

RATHER (VOICE OVER)

TO JAY KEASLING—ONE OF THE FOUNDERS OF THIS FIELD—THE REAL RISK LIES IN NOT MOVING SCIENCE FORWARD.

KEASLING

I'm not so naive to think that we can solve all our problems by engineering biology. But I think there are a few really important problems that we can solve by engineering biology and so we should be doing it.

ACT 4: SECURITY

DAN RATHER (VOICE OVER)

NEW YORK'S BOROUGH OF BROOKLYN IS KNOWN FOR ITS INDEPENDENT STREAK. THIS

RAMSHACKLE BUILDING IN THE DOWNTOWN AREA IS NO EXCEPTION... IT'S HOME TO ARTISTS, DESIGNERS, AND START-UPS. AND ON THE TOP FLOOR, YOU'LL FIND A GROUP THAT'S BRINGING THE DO-IT-YOURSELF SPIRIT INTO SURPRISING NEW TERRITORY... GENETICS.

ELLEN JORGENSEN,
CO-FOUNDER AND PRESIDENT OF GENSPACE

Every gene in the world starts with the three letter code ATG..

RATHER (VOICE OVER)

AT GENSPACE, A SELF-PROCLAIMED COMMUNITY LABORATORY, YOU CAN TAKE A CLASS IN THE BASICS OF SYNTHETIC BIOLOGY... JUST LIKE YOU MIGHT TAKE A COOKING CLASS OR DANCE LESSONS.

JORGENSEN

In the old days, you really had to be a biologist in order to do this kind of stuff. Now you can just get on the phone to a gene synthesis company or on the computer and you can order up a gene. And in eight weeks you'll have it.

RATHER (VOICE OVER)

ELLEN JORGENSEN IS ONE OF THE FOUNDERS OF GENSPACE. SHE HAS A PHD IN MOLECULAR BIOLOGY AND WORKED FOR YEARS IN THE BIOTECH INDUSTRY... BUT SHE LEFT THAT WORLD BEHIND TO HELP BRING GENETICS TO THE MASSES.

OLIVER MEDVEDIK,
GENSPACE CO-FOUNDER

These freezers here, these came from Home Depot.

RATHER (VOICE OVER)

TO LAUNCH GENSPACE, JORGENSEN TEAMED UP WITH ANOTHER PHD BIOLOGIST... OLIVER MEDVEDIK.

MEDVEDIK

We have a lot of equipment coming from either donations, through eBay. An incubator I bought that's in that room, brand new would cost about approximately ten thousand dollars. I got the same one for about—I'm trying to remember now—four hundred dollars, four hundred and fifty dollars. It works perfectly.

RATHER (VOICE OVER)

GENSPACE IS ALSO A PLACE WHERE MEMBERS CAN COME TO WORK ON THEIR OWN PROJECTS...

MEDVEDIK

Basically, all you have to do is email us, come in off the street and say “ this is what I know and this is what I’d like to do.”

RATHER (VOICE OVER)

TO TAKE JUST ONE EXAMPLE, A GROUP OF HIGH SCHOOLERS WANTED TO FIND OUT IF THE TUNA AT A LOCAL SUSHI RESTAURANT WAS REALLY TUNA. THEY TESTED THE FISH’S DNA... AND DISCOVERED THAT IT WASN’T.

JORGENSEN

It is mind blowing that someone can do this stuff in a casual setting like this.

RATHER (VOICE OVER)

THIS MOVEMENT OF DO-IT-YOURSELF OR DIY BIOLOGISTS IS GROWING... THERE ARE ONLINE FORUMS WHERE PEOPLE TRADE TIPS AND ASK QUESTIONS. AND COMMUNITY LABS ARE POPPING UP AROUND THE COUNTRY.

JORGENSEN

We get inquiries at least once a month from someone who wants to set one up. Someone in Tennessee, or Atlanta, or Seattle.

RATHER (VOICE OVER)

BUT THE QUESTION OF JUST HOW MUCH AN AMATEUR MIGHT BE ABLE TO DO... IN A COMMUNITY LAB LIKE GENSPACE OR IN THEIR OWN GARAGE... HAS SOME PEOPLE WORRIED. WHAT IF THEY WANTED TO DO SOMETHING HARMFUL... LIKE SYNTHESIZING A DEADLY VIRUS?

IT’S AN IDEA THE MEDIA HAS JUMPED ON. BUILDING PATHOGENS FROM SCRATCH HAS LONG BEEN POSSIBLE IN HIGH-TECH LABS. IN 2002, SCIENTISTS AT STONY BROOK UNIVERSITY SUCCESSFULLY RECREATED THE POLIO VIRUS USING DNA FRAGMENTS THEY OBTAINED FROM A MAIL-ORDER COMPANY.

IT WOULD STILL BE EXCEEDINGLY DIFFICULT FOR AN AMATEUR TO DO IT... BUT WITH

DNA TECHNOLOGY DEVELOPING AT BREAKNECK SPEED, A DIY BIOTERRORIST IS INCREASINGLY PLAUSIBLE.

ED YOU IS SOMEONE WHO WORRIES ABOUT THAT KIND OF THING FOR A LIVING. HE'S A SUPERVISORY SPECIAL AGENT IN THE FBI'S BIOLOGICAL COUNTERMEASURES UNIT.

RATHER

I'm of a generation old enough to remember when there was no cure for polio. And just to take one example, the idea that someone could create a-- polio virus in their garage is pretty scary to me. Does it scare you?

ED YOU,
SUPERVISORY SPECIAL AGENT, FBI

This field is moving so rapidly. We realize that-- the barrier to entry to be able to do something like that scenario-- is getting lower and lower.

RATHER

BUT IF YOU EXPECT THE FBI TO LOOK AT GROUPS LIKE GENSPACE AS ADVERSARIES, YOU'LL BE SURPRISED TO LEARN THAT THE OPPOSITE IS TRUE: AGENT YOU SEES THEM AS PARTNERS IN THE FIGHT. IN FACT, A MAJOR PART OF HIS MISSION IS RALLYING SCIENTISTS AND AMATEURS ALIKE TO THE CAUSE OF SECURITY.

YOU

It's impossible for us to be everywhere and see everything. It's not our mandate. It's-- and we just don't have the resources to be able to do something like that. So again, who best to be able to detect that kind of activity than the people who are working in the field themselves.

RATHER

I live in New York, and on subways and buses, they have this, "If you see something, say something." Is this what you are saying to the scientists who work in these areas?

YOU

Yes. But it should be more than just an emergency 911 type call. They're in a position, if they understand what some of the security concerns could be, what the risks and vulnerabilities might be, they can inform us about that. So we, in effect, are-- using their ability, their subject matter expertise, to help us in our-- our mission of prevention and protection.

JORGENSEN

The FBI is more supportive of us than the media.

RATHER (VOICE OVER)

AND IN THE FBI'S VIEW, TRAINING MORE PEOPLE IN THE BASICS OF BIO-TECHNOLOGY IS A GOOD THING.

JORGENSEN

If you see something say something, so if you don't know what you're looking at, then you can't say anything. So the more people who are educated, the better off they think they are.

YOU

We have established this understanding, and I would say a partnership, between even this amateur biology community with law enforcement. And I think that's incredibly powerful.

RATHER

When you say "FBI agent," the first thing that pops into a lot of people's minds, including my own, is an agent, holstered weapon, collaring a bad guy, and leading him off in handcuffs. But what you're talking about is an FBI that's building relationships. Is this new, uncharted territory for the Bureau?

YOU

Not so much, but I will say that September 11th was a huge wakeup call --what you've mentioned about the prototypical FBI agent going out and catching the bad guy-- we are still very good at that. But that's still inherently reactive. In order to prevent a 9/11 from happening again, we need to be proactive.

RATHER (VOICE OVER)

AND WHAT COULD BE MORE PROACTIVE THAN TRYING TO WIN OVER THE NEXT GENERATION OF SCIENTISTS?

YOU (AT IGEM PRESENTATION)

The 21st century is going to be the century of the life sciences and you all are on the leading edge of that revolution.

RATHER (VOICE OVER)

THE FBI IS A SPONSOR OF IGEM... THE GENETIC ENGINEERING SCIENCE COMPETITION FOR COLLEGE STUDENTS.

AGENT YOU IS A TRAINED BIOLOGIST, SO HE HAS NO PROBLEM TALKING SHOP WITH THE STUDENTS ABOUT MICROBES AND MOLECULES... WHILE ALSO URGING THEM TO

SEE THE IMPORTANCE OF SAFETY AND SECURITY.

RATHER

How do the students react to having an FBI agent in their midst? You must've had some very interesting conversations?

YOU

The very first question is, "Why is the FBI here?" (LAUGHTER) And-- but th-- the really nice response is that once we talk about some of the very things that-- that I've discussed with you, the response is, "Oh. That makes sense."

And the very next question is, "How do I become an agent?" (LAUGHTER) And that's precisely what we're looking for as well, too--

RATHER (VOICE OVER)

ACCORDING TO AGENT YOU, THE FBI'S PROACTIVE APPROACH HAS ALREADY PROVEN ITS WORTH.

YOU

Just a few months ago-- there was a-- sentencing-- of an individual who ordered toxins through the internet, but it was just below the regulated amount. It was a savvy customer service representative on the other end that realized that this just didn't make sense. And they contacted their local FBI WMD coordinator and it turned out that this individual was fraudulently trying to collect-- this dangerous biological toxin. And as a result we were able to investigate it, and apprehend him, and stop him. But it really did take someone who heard our message and saw something that didn't make sense and actually took action and reported it.

RATHER (VOICE OVER)

THE IDEA OF SOMETHING LIKE THAT SLIPPING THROUGH THE CRACKS IS WHAT KEEPS AGENT YOU UP AT NIGHT. BUT HE SEES SYNTHETIC BIOLOGY AS MORE THAN JUST A NEW SOURCE OF NATIONAL SECURITY THREATS... IT CAN ALSO BE A POWERFUL DEFENSE AGAINST OTHER, VERY REAL DANGERS.

YOU

There's a-- there's a quote that's used often, that, "Th-- the biggest-- bioterrorist is Mother Nature." And-- (LAUGHTER) it's-- it's all too true. If we drive away this line of research in the name of security, then we're developing a whole different type of vulnerability and national security risk, because we're now curtailing-- the-- developing new vaccines, new medicines, new countermeasures for that very-- p-- real

threat. We're never gonna get zero risk, it is that balance game and that's why we absolutely need the partnership with the scientific community, itself.

RATHER (VOICE OVER)

WHEN WE COME BACK... DNA... THROUGH THE EYES OF AN ARTIST. SO STAY WITH US.

ACT 5: DNA ARTIST

DAN RATHER (ON CAMERA)

WELCOME BACK. THE IMPACT OF SYNTHETIC BIOLOGY WILL GO FAR BEYOND RESEARCH LABS, UNIVERSITY CLASSROOMS, AND GOVERNMENT AGENCIES. AFTER ALL, DNA SHAPES WHO WE ARE... AND AS SUCH, IS DEEPLY PERSONAL. SO WE THOUGHT IT WOULD BE FITTING TO INCLUDE A VERY DIFFERENT PERSPECTIVE ON THIS NEW TECHNOLOGY... AND ITS IMPLICATIONS FOR OUR SOCIETY, OUR CULTURE, AND OUR SENSE OF SELF.

RATHER (VOICE OVER)

HEATHER DEWEY-HAGBORG IS AN ARTIST... BUT INSTEAD OF A TRADITIONAL STUDIO, SHE DOES MUCH OF HER WORK IN A LABORATORY. HER LATEST PROJECT IS A SERIES OF PORTRAITS... BUT OF PEOPLE SHE'S NEVER MET. INSTEAD, SHE ANALYZES THEIR DNA... AND MAKES LIFELIKE SCULPTURES, BASED ON THEIR GENES.

HEATHER DEWEY-HAGBORG

So what I want to know is how much can I find out about you from something that you accidentally leave behind. From some trace of your genetic material.

RATHER (VOICE OVER)

SHE CALLS THE PROJECT STRANGER VISIONS. THE STRANGERS IN QUESTION ARE PEOPLE WHOSE GENETIC MATERIAL SHE FINDS ON THE SIDEWALKS AND SUBWAYS OF NEW YORK CITY.

DEWEY-HAGBORG

I just keep my eyes open for hairs, cigarette butts, chewing gum, anything that I think might contain some genetic material.

DEWEY-HAGBORG

And there's a very nice piece of chewing gum. You tend to shed your cheek cells in your saliva. And the saliva soaks into the chewing gum and the cigarette butt filter. For me it has become a very conscious awareness that you know, every time I run my hand through my hair, I'm donating my DNA to the collective environment.

RATHER (VOICE OVER)

SHE TAKES HER SAMPLES TO THE COMMUNITY LABORATORY GENSPACE, FOR SOME DO-IT-YOURSELF FORENSIC ANALYSIS. IT MIGHT LOOK COMPLICATED, BUT DEWEY-HAGBORG—WHO HAS NO FORMAL TRAINING IN THIS—SAYS THAT ANYONE CAN LEARN THE PROCESS. ALL IT TAKES IS A LITTLE PATIENCE.

DEWEY-HAGBORG

A lot of the lab work really is like cooking. Where you're following this recipe and they just call it a protocol but it's basically a recipe. It's a series of steps and ingredients and you just have to be very precise about it.

DEWEY-HAGBORG

I extract DNA from the samples and then I take that and use a technique called PCR or *polymerase chain reaction* to look at specific parts of the genome that code for physical traits that I'm interested in.

RATHER (VOICE OVER)

AND WHAT CAN SHE FIND OUT ABOUT YOU FROM A DISCARDED PIECE OF CHEWING GUM? THINGS LIKE ETHNICITY, HAIR AND EYE COLOR, AND FRECKLES. SOME THINGS, SHE KNOWS FOR SURE. OTHERS—LIKE YOUR TENDENCY TO BE OVERWEIGHT—ARE JUST PROBABILITIES.

DEWEY-HAGBORG

The fact that I can figure out physical characteristics also means that I can figure out anything else. Predisposition for diabetes, cancer, I could potentially know more about you than your doctor does. So I think this project is pointing towards some of those uncomfortable questions, and saying: This is no longer science fiction. This is possible today. What are we going to make of that?

RATHER (VOICE OVER)

SHE BRINGS THIS JUMBLE OF PHYSICAL TRAITS INTO A 3-D MODELING PROGRAM, SCULPTING A VIRTUAL PORTRAIT THAT SHE SENDS OFF TO BE MANUFACTURED. OF COURSE, THERE'S STILL A LOT WE DON'T KNOW ABOUT HOW GENES SHAPE OUR PHYSICAL APPEARANCE. AND SO THE FINAL RESULTS OWE A LOT TO DEWEY-HAGBORG'S ARTISTIC INSTINCTS.

DEWEY-HAGBORG

So here's an example of what that might look like when it comes out of the 3D printer. And this happens to be the model that I generated from my own genetic material. Half of the people who come to a genetic exhibit and see this, look at it and say, "Huh, doesn't look anything like you." And the other half come in and say "Woah, looks just like you."

RATHER (VOICE OVER)

AS SCIENCE ADVANCES, THE GENETIC MATERIAL YOU LEAVE BEHIND IN YOUR DAILY LIFE WILL REVEAL MORE AND MORE ABOUT YOU. WHICH IS EXACTLY WHAT DEWEY-HAGBORG WANTS YOU TO THINK ABOUT WHEN YOU SEE HER WORK.

DEWEY-HAGBORG

What I do hope is that you could look at one of these portraits and look at the time and the day and the place where I collected the sample and you could say that could be me. That could be my hair, that could be my cigarette butt or my chewing gum. Or my lollipop stick. And that you could wonder if someone have access to this very personal information.

RATHER (ON CAMERA)

I'LL BE BACK IN A MOMENT, WITH A FINAL THOUGHT... SO STAY WITH US.

ACT 6: FINAL THOUGHT

DAN RATHER (ON CAMERA)

FINALLY TONIGHT, THIS THOUGHT... SYNTHETIC BIOLOGY IS PROMISING BIG THINGS, FROM MEDICINE TO ENERGY TO MANUFACTURING. IT'S IMPOSSIBLE TO KNOW WHETHER ANY SPECIFIC PREDICTION WILL COME TRUE, OR WHETHER ANY PARTICULAR RESEARCH WILL PAY OFF. BUT ONE THING SEEMS CERTAIN: CHANGE, BIG CHANGE, IS ON THE WAY... AND WE MAY HAVE TO RETHINK THE VERY QUESTION OF WHAT MAKES LIFE... LIFE.

AS A SOCIETY, IT IS CRITICAL THAT WE NOT SHY AWAY FROM THE DIFFICULT QUESTIONS SURROUNDING SYNTHETIC BIOLOGY. BUT IT IS ALSO TRUE THAT A LOT OF VERY THOUGHTFUL SCIENTISTS BELIEVE THIS TECHNOLOGY COULD DEFINE OUR WORLD FOR DECADES TO COME. AND IF AMERICA WANTS TO REMAIN THE GLOBAL LEADER IN SCIENCE, WE CANNOT AFFORD TO MISS OUT.

AND THAT'S OUR PROGRAM FOR TONIGHT...WE ALWAYS LIKE HEARING WHAT YOU HAVE TO SAY. SO PLEASE JOIN IN THE DISCUSSION ON OUR FACEBOOK PAGE, OR SEND YOUR COMMENTS TO VIEWER@AXS.TV... FROM NEW YORK, FOR AXS TV, DAN RATHER REPORTING. GOOD NIGHT.