

1

00:00:00,000 --> 00:00:10,271

In ultraviolet light, a technician purifies the very essence of life.

2

00:00:10,271 --> 00:00:13,276

Scientists have acquired profound new abilities.

3

00:00:13,276 --> 00:00:19,284

They can read the secret code of life and change its genetic structure.

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00:00:19,284 --> 00:00:22,288

The greatest mysteries may soon be solved.

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00:00:22,288 --> 00:00:27,295

We could discover how a human being develops from a single egg.

6

00:00:27,295 --> 00:00:31,301

We might even find out what causes life.

7

00:00:31,301 --> 00:00:40,313

Music

8

00:00:40,313 --> 00:00:46,322

Beyond the outer planets of our solar system, space curves off into the vast abyss of the universe.

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00:00:46,322 --> 00:00:53,332

Scientists believe our universe exploded into being some 15 billion years ago.

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00:00:53,332 --> 00:00:59,340

It formed countless galaxies of 100 billion stars.

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00:00:59,340 --> 00:01:03,346

On our planet, life developed over 3 billion years.

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00:01:03,346 --> 00:01:07,351

It evolved from simple virus-like particles to plants, animals,

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00:01:07,351 --> 00:01:14,361

and the incredibly complex organism that is man.

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00:01:14,361 --> 00:01:20,370

Since the dawn of history, people have wondered, what is the essence of life?

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00:01:20,370 --> 00:01:24,375

Music

16

00:01:24,375 --> 00:01:31,385

Several hundred years ago, pioneers with microscopes discovered the basic building block of life, the cell.

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00:01:31,385 --> 00:01:33,388

Cells are the primary unit of life.

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00:01:33,388 --> 00:01:37,393

100 trillion cells comprise a human being.

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00:01:37,393 --> 00:01:46,406

Billions of muscle cells, skin cells, nerve cells, and blood cells all working together to orchestrate our every movement.

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00:01:46,406 --> 00:01:54,417

The most remarkable ability of the cell is its capacity to grow and divide.

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00:01:54,417 --> 00:02:04,431

Fertilized egg cells begin the process of development that in 21 days will culminate in the birth of baby mice.

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00:02:04,431 --> 00:02:08,437

What marvelous control system governs this miracle of growth?

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00:02:08,437 --> 00:02:15,447

What mysterious forces cause the development of a heart?

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00:02:15,447 --> 00:02:22,456

Since the early 1950s, the science of biology has undergone a revolutionary change.

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00:02:22,456 --> 00:02:28,465

Scientists have begun to unravel the innermost secrets of the cell.

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00:02:28,465 --> 00:02:32,470

Within each cell are tiny structures called chromosomes.

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00:02:32,470 --> 00:02:37,477

They contain the information cells need to live and grow.

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00:02:37,477 --> 00:02:43,486

Just before cells divide, these chromosomes copy themselves exactly.

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00:02:43,486 --> 00:02:50,496

They transmit the blueprint of life from generation to generation.

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00:02:50,496 --> 00:02:55,503

The chromosomes are composed of thousands of incredibly small units called genes.

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00:02:55,503 --> 00:03:03,514

The genes order the cell to make molecules which are vital to life.

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00:03:03,514 --> 00:03:07,520

Genes are made of a molecule called DNA.

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00:03:07,520 --> 00:03:11,525

Its twisted strands store the genetic information in a simple code.

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00:03:11,525 --> 00:03:17,534

DNA is composed of only four chemical units endlessly repeated in various combinations.

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00:03:17,534 --> 00:03:24,543

The magic of DNA is how these simple units determine all the forms of life we know.

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00:03:24,543 --> 00:03:30,552

The wonder of DNA is most obvious in the phenomenal likeness of identical twins.

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00:03:30,552 --> 00:03:36,560

Each girl has inherited precisely the same set of genetic instructions.

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00:03:36,560 --> 00:03:43,570

They are what they are because of some hundred thousand genes written in the language of DNA.

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00:03:43,570 --> 00:03:52,583

So incredibly precise is this genetic code that Lisa and Ingrid are alike down to their freckles and the tiny nicks on their ears.

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00:03:52,583 --> 00:03:58,591

As scientists expand their knowledge of the code of life, it is becoming easier to change life.

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00:03:58,591 --> 00:04:01,595

To alter is genetic structure.

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00:04:01,595 --> 00:04:05,601

Chromosomes, genes and DNA are tiny chunks of matter.

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00:04:05,601 --> 00:04:10,608

They can be engineered, cut up and rearranged in endless combinations.

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00:04:10,608 --> 00:04:15,615

The technology can be developed, some of it already exists.

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00:04:15,615 --> 00:04:19,620

In dealing with human life, biologists are much more limited.

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00:04:19,620 --> 00:04:24,627

Once a child is born, its genetic structure is fixed, unchangeable.

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00:04:24,627 --> 00:04:29,634

If the genetic instructions are faulty, little can be done.

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00:04:29,634 --> 00:04:33,640

The adult could be a crippling disease.

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00:04:33,640 --> 00:04:39,648

It is possible, however, to detect some genetic defects during pregnancy.

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00:04:39,648 --> 00:04:46,658

Because her risk increases with age, this woman has decided to have a test.

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00:04:46,658 --> 00:04:51,665

An obstetrician withdraws some fluid from the sac surrounding the growing fetus.

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00:04:51,665 --> 00:04:58,675

In the fluid are a few of its cells.

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00:04:58,675 --> 00:05:06,686

The cells are added to a nutrient broth in which they can live and grow.

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00:05:06,686 --> 00:05:14,698

Placed in an incubator, the cells multiply until there are enough for the test.

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00:05:14,698 --> 00:05:19,705

A technician searches for cells in which the chromosomes are easy to see.

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00:05:19,705 --> 00:05:22,709

She checks the size and shape of each one.

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00:05:22,709 --> 00:05:27,716

In this case, the chromosomes looked perfectly normal.

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00:05:27,716 --> 00:05:34,726

However, when the genetic structure of healthy cells is damaged, the result may be cancer.

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00:05:34,726 --> 00:05:41,735

Normal genes switch off while malignant genes switch on.

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00:05:41,735 --> 00:05:50,748

Renegade cells grow out of control. They invade the tissues around them and form tumors.

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00:05:50,748 --> 00:05:55,755

The fast growing tumor on this mouse's back will rapidly kill it.

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00:05:55,755 --> 00:06:00,762

At the Lawrence Livermore Lab, some of the tumor cells are removed.

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00:06:00,762 --> 00:06:04,768

Their DNA is stained with a special dye.

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00:06:04,768 --> 00:06:09,775

When the blue laser beam hits the DNA, it causes tiny flashes of light.

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00:06:09,775 --> 00:06:12,779

These flashes are detected electronically.

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00:06:12,779 --> 00:06:20,790

Their pattern is typical of cancer cells which have more DNA than normal cells.

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00:06:20,790 --> 00:06:25,797

The scientists have another extremely sensitive way to check chromosomes.

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00:06:25,797 --> 00:06:36,812

An electronic scanner hooked up to a computer forms pictures which show the precise amount of DNA in each chromosome.

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00:06:36,812 --> 00:06:46,826

So exact is this system that it tells the difference between chromosomes inherited from the mother and those from the father.

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00:06:46,826 --> 00:06:54,838

With such computerized technology, we begin our journey into advanced genetic research.

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00:06:54,838 --> 00:07:03,850

To probe the mysteries of cell division, a powerful laser beam is used to perform surgery on cells and chromosomes.

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00:07:03,850 --> 00:07:13,864

Dr. Michael Burns of the University of California at Irvine has developed this remarkable technique of genetic engineering.

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00:07:13,864 --> 00:07:24,880

The lens focuses the laser light into a tiny beam which cuts through cells like a microscopic scalpel.

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00:07:24,880 --> 00:07:37,898

The beam is so precise that it can be aimed at individual chromosomes and even used to snip off pieces containing a few genes.

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00:07:37,898 --> 00:07:46,911

Dr. Burns finds two chromosomes and hits them with the laser.

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00:07:46,911 --> 00:07:54,922

The cell is not destroyed. It continues to divide, but the chromosomes hit by the laser are expelled.

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00:07:54,922 --> 00:07:58,927

Their messages will not be passed on to other cells.

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00:07:58,927 --> 00:08:06,939

What comes next is another amazing feat of microsurgery, the manipulation of cells a thousandth of an inch across.

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00:08:06,939 --> 00:08:14,950

Carefully, all the cells around the one hit by the laser are scraped away.

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00:08:14,950 --> 00:08:20,958

A nutrient fluid is added so that the single cell remaining can reproduce itself.

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00:08:20,958 --> 00:08:29,971

Over the next few weeks, that single cell will divide into a colony of identical cells.

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00:08:29,971 --> 00:08:40,986

Mysteriously, the destroyed chromosome is replaced by the remaining ones, thus restoring normal chromosome number to the cells.

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00:08:40,986 --> 00:08:46,995

Other biologists have developed more precise techniques of genetic engineering.

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00:08:46,995 --> 00:08:55,006

They can chop DNA molecules into pieces without destroying the molecules' ability to play the game of life.

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00:08:55,006 --> 00:09:05,020

If they could link up these pieces in the right combination, they might solve the mysteries of the gene.

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00:09:05,020 --> 00:09:16,035

If they could insert bits of DNA into living cells, they could create forms of life with new genetic structures.

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00:09:16,035 --> 00:09:21,042

Their testing ground has been a tiny bacterium called E. coli.

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00:09:21,042 --> 00:09:27,051

It lives in the human intestine where its functions are largely unknown.

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00:09:27,051 --> 00:09:41,070

The molecular biologists have found a way to splice genes from animals and plants into E. coli's well-known genetic structure.

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00:09:41,070 --> 00:09:52,086

So cooperative are these bacteria that they willingly accept the foreign DNA and copy it as if it were their own.

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00:09:52,086 --> 00:09:55,090

A revolution in medicine may be on the horizon.

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00:09:55,090 --> 00:10:01,098

Already, gene splicing is being used to attack the human disease of diabetes.

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00:10:01,098 --> 00:10:06,105

Scientists' long-time dream of genetic engineering is at hand.

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00:10:06,105 --> 00:10:11,112

They are getting closer to the secrets of life.

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00:10:15,118 --> 00:10:21,126

Since the discovery of DNA, biologists have been manipulating the very essence of life.

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00:10:25,132 --> 00:10:30,139

Today, they can take DNA out of one cell and insert it into another.

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00:10:30,139 --> 00:10:33,143

They can even mix the genes of different species.

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00:10:33,143 --> 00:10:40,153

By transplanting animal genes into bacteria, they hope to find out how these genes work and are controlled.

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00:10:45,160 --> 00:10:52,170

The process begins when a strain of bacteria is given an ample supply of food and gently shaken.

100

00:11:01,182 --> 00:11:07,191

In less than 24 hours, each bacterium can multiply 100 billion fold.

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00:11:11,197 --> 00:11:19,208

After the bacteria are harvested, a detergent bursts open their cell walls and sticky DNA strands spill out.

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00:11:21,211 --> 00:11:25,216

Most of the DNA clumps together in a disarray-tangle.

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00:11:26,218 --> 00:11:32,226

But nearby are tiny loops of DNA called plasmids.

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00:11:36,232 --> 00:11:40,237

They are the key to the new technology of gene splicing.

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00:11:40,237 --> 00:11:44,243

They will accept any genes the biologists can stitch into them.

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00:11:45,244 --> 00:11:50,251

A fast-spinning centrifuge separates the plasmids from the rest of the DNA.

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00:11:54,257 --> 00:11:59,264

Under ultraviolet light, a fluorescent dye makes the plasmid band visible.

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00:12:02,268 --> 00:12:06,274

Carefully, the precious plasmids are removed.

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00:12:07,275 --> 00:12:10,279

Now come the most crucial steps.

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00:12:10,279 --> 00:12:14,285

In this simulation, a special enzyme is added to the plasmids.

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00:12:14,285 --> 00:12:20,293

By compare of microscopic scissors, it snips open their DNA molecules at specific points.

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00:12:20,293 --> 00:12:25,300

Other snipped genes can now be added to the open plasmid loops.

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00:12:27,303 --> 00:12:32,310

The best way to do this is to use a special enzyme.

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00:12:32,310 --> 00:12:36,316

The new plasmid band is used to make the open plasmid loops.

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00:12:36,316 --> 00:12:41,323

The foreign DNA joins the plasmids, creating a new DNA molecule.

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00:12:41,323 --> 00:12:48,332

The resulting loops, called recombinant DNA, combine animal genes with bacterial genes.

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00:12:48,332 --> 00:12:54,341

They will be reinserted into other bacteria, giving those bacteria new genes.

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00:12:55,342 --> 00:13:01,351

When the bacteria multiply, their new blueprint is copied over and over.

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00:13:03,354 --> 00:13:09,362

Thus, science can make life forms with new combinations of genes.

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00:13:12,366 --> 00:13:18,375

Dr. William Rudder is chairman of the biochemistry department at the University of California, San Francisco.

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00:13:18,375 --> 00:13:23,382

The possibilities for recombinant DNA technology are simply enormous.

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00:13:24,383 --> 00:13:32,394

Not only are we going to revolutionize the understanding of the human genome and for genetics in general,

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00:13:32,394 --> 00:13:37,401

but we will have profound effects on many aspects of biomedical science.

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00:13:38,403 --> 00:13:43,410

Over 40 million people are affected by the genetic disease called diabetes.

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00:13:43,410 --> 00:13:49,418

In the United States alone, more than a million people inject insulin each day in order to stay alive.

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00:13:49,418 --> 00:13:53,424

This insulin comes from the pancreas gland of animals.

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00:13:53,424 --> 00:13:58,431

It is in short supply worldwide and often produces undesirable side effects.

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00:13:59,432 --> 00:14:06,442

My colleagues and I have been studying the expression of the insulin gene in the embryonic rat pancreas for several years.

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00:14:06,442 --> 00:14:12,450

And one day I attended a faculty meeting at which Herbert Boyer and Howard Goodman were discussing their work on recombinant DNA.

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00:14:12,450 --> 00:14:14,453

This excited me a great deal.

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00:14:14,453 --> 00:14:18,459

And I cornered these two individuals after the meeting and said,

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00:14:18,459 --> 00:14:22,464

Herb and Howard, we just must clone the insulin gene.

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00:14:22,464 --> 00:14:27,471

What the scientists proposed to do would have seemed impossible ten years ago.

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00:14:27,471 --> 00:14:31,477

Of the thousands of genes in each cell of the laboratory rat,

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00:14:31,477 --> 00:14:36,484

they wanted to isolate the single gene that makes insulin in the rat's pancreas gland.

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00:14:37,485 --> 00:14:46,498

Then they would transplant this gene into bacteria hoping to create a microbe with the insulin producing ability of a mammal.

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00:14:54,509 --> 00:14:57,513

If they could make it work for the insulin gene,

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00:14:57,513 --> 00:15:02,520

it might become possible to make dozens of important hormones and drugs.

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00:15:06,526 --> 00:15:11,533

A group of scientists at the university began to collaborate on the experiments.

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00:15:14,537 --> 00:15:17,541

So we obtained the insulin producing cells from several hundred rats

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00:15:17,541 --> 00:15:21,547

and extracted from them the chemicals from which we could get the DNA.

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00:15:24,551 --> 00:15:27,555

Axolorec took this material, inserted it into a plasmid,

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00:15:27,555 --> 00:15:32,562

and placed the plasmid into a strain of bacteria that could only grow in the laboratory.

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00:15:33,564 --> 00:15:38,571

These steps of the experiment were carried out under strict conditions of containment.

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00:15:39,572 --> 00:15:45,581

Howard Goodman is professor of biochemistry at the University of California, San Francisco.

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00:15:45,581 --> 00:15:50,588

We had been working on the cloning of rat insulin for about a year.

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00:15:50,588 --> 00:15:54,593

We had many technical difficulties and we began to overcome them.

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00:15:54,593 --> 00:15:57,597

But it wasn't until the moment I saw this film,

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00:15:57,597 --> 00:16:00,602

which was the analysis of the gene that we had cloned

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00:16:00,602 --> 00:16:04,607

that we really knew we had the rat insulin gene in the bacteria.

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00:16:05,609 --> 00:16:09,614

The next step is to show that the genes which we have transplanted to the bacteria

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00:16:09,614 --> 00:16:12,618

can actually work and produce insulin.

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00:16:12,618 --> 00:16:16,624

We'll then try to insert human genes into bacteria instead of the rat genes.

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00:16:16,624 --> 00:16:22,632

If we can get these genes to work, this would provide a virtually inexhaustible supply of human insulin,

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00:16:22,632 --> 00:16:26,638

much better than animal insulin since it would have no undesirable side effects.

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00:16:28,641 --> 00:16:34,649

Eventually, in a generation or so, we might be able to do something which is really fantastic.

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00:16:34,649 --> 00:16:38,655

It might be possible to rejuvenate the defective cells of the diabetics

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00:16:38,655 --> 00:16:43,662

so that they would produce insulin in a normal fashion, thus the disease would be cured.

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00:16:47,667 --> 00:16:54,677

In the future, bacteria modified with recombinant DNA may be grown in industrial amounts.

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00:16:58,683 --> 00:17:03,690

The bacteria could produce hormones like insulin and other important drugs.

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00:17:03,690 --> 00:17:11,701

New fast-growing strains of bacteria or algae could be used in vast amounts as animal feed or fuel.

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00:17:17,710 --> 00:17:21,715

A whole new technology will be needed to pick the desired bacteria.

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00:17:27,724 --> 00:17:40,742

Automation will be used to inoculate, incubate and photograph bacteria.

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00:17:49,754 --> 00:17:53,760

The system produces thousands of photographs under computer control.

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00:17:53,760 --> 00:17:58,767

These could be used to select the most productive bacteria for industrial use.

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00:18:01,771 --> 00:18:06,778

Breakthroughs in genetic engineering may open up a whole new realm of biology.

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00:18:06,778 --> 00:18:13,788

Until recently, it has been very difficult to identify specific genes on animal chromosomes.

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00:18:13,788 --> 00:18:20,798

But with new techniques of gene splicing, scientists have begun to map the uncharted terrain of the chromosome.

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00:18:24,803 --> 00:18:31,813

Stanford University biologists have made a remarkable photograph of fruit fly chromosomes.

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00:18:31,813 --> 00:18:41,827

While trying to locate a certain gene on one chromosome, they found to their surprise that the gene's DNA code was repeated dozens of times.

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00:18:41,827 --> 00:18:47,836

To explain this important finding, the scientists came up with a new idea.

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00:18:48,837 --> 00:18:56,848

Just as each letter of the alphabet is found in many different words, each gene copy may play a different role in the life process of the fly.

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00:18:59,852 --> 00:19:09,867

Biologists are now busy testing this idea. It could be the key to the miracle of growth, helping explain how a human being develops from a fertilized egg.

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00:19:10,868 --> 00:19:16,876

The new molecular biology is leading to cures for genetic diseases.

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00:19:16,876 --> 00:19:21,883

It may enable us to engineer our own genes and influence our destiny.

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00:19:21,883 --> 00:19:27,892

It might even lead to complete knowledge of the secret of life.

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00:19:27,892 --> 00:19:35,903

But is it possible to explain life in terms of chemicals and molecules, or to explain life in terms of life?

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00:19:35,903 --> 00:19:42,913

Or are there profound mysteries beyond the gene?

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00:19:46,918 --> 00:19:55,931

While raising hopes of great advances in medicine and biology, recombinant DNA research has also created a major controversy.

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00:19:55,931 --> 00:19:59,937

Tinkering with the stuff of life is not without its risks.

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00:20:00,938 --> 00:20:06,946

Some people are afraid that a bit of DNA spliced into a harmless bacterium could create a deadly germ.

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00:20:06,946 --> 00:20:12,955

Others fear that mixing genes from different species could have unpredictable effects on evolution.

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00:20:12,955 --> 00:20:18,963

Government agencies have enacted strict controls for recombinant DNA research.

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00:20:18,963 --> 00:20:24,972

Most scientists say that if these guidelines are followed, genetic engineering is not dangerous.

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00:20:24,972 --> 00:20:32,983

With today's technology, we can only add a few foreign genes to bacteria.

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00:20:32,983 --> 00:20:39,993

But a hundred years from now, we may be able to mold genetic structure as freely as a sculptor shapes clay.

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00:20:39,993 --> 00:20:47,002

The question is, will we be ready for the power to change life?

188

00:20:48,004 --> 00:21:03,025

Coming up next in search of continues with a probe into the eerie possibility of artificially creating child prodigies.

189

00:21:03,025 --> 00:21:10,035

Then on FBI, the untold stories, a woman kills the state prosecutor who put her husband behind bars,

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00:21:10,035 --> 00:21:13,039

but was something more than love involved.

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00:21:13,039 --> 00:21:21,050

And later tonight, history's greatest blunders continues with the sinking of the Titanic and the Andrea Doria

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00:21:21,050 --> 00:21:27,059

at 9 Eastern 10 Pacific here on the History Channel, where the past comes alive.