Can you tell if any of these animals are transgenic?
From Wolf to Poodle - Taming and Changing Animals

The Science of Breeding

Developing a Transgenic Animal

Healthier Foods, Healthier Animals

Meanwhile, Back on the Pharm: Animals Making Medicine

Animal Models of Human Disease

Our Long Relationship with Animals

Profile

Vernon G. Pursel, Animal Physiologist

Class Project

Predicting Traits

Cover:
You can’t tell from looking at them if animals are transgenic—meaning they carry an added gene. The two piglets on the left of the upper left photo are transgenic. They are part of a research project that hopes to find an inexpensive way to produce a valuable medical protein. They carry a gene that will make this protein in their milk when they grow up.

Photo Credits:
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Lower left: Penn State Photographic Services
Lower middle: Terry Wild Studios
Since the beginning of our time on earth, people have relied on plants and animals for survival – and we have bred those animals and plants with traits we have found most helpful. In prehistoric days, we tamed the wolf and created the dog, and we domesticated a wild grain to create corn. Throughout the ages, we have selected plants and animals with valuable traits and bred them. Hunters bred dogs with specialized skills such as sniffing, retrieving, or chasing. Farmers cultivated plants to produce more grain and cows to give more milk. Breeding across similar species gave us the hardy mule (a cross between a donkey and a horse) and new fruits and vegetables such as the tangelo (a cross between a grapefruit and a tangerine).

Today, genetic engineering allows us to breed transgenic plants and animals. The meaning of the word “transgenic” has changed over time. Originally it meant using genetic engineering to transfer the genes from one species to another species. For instance, we transferred an insect-fighting gene from a bacterium to a tomato to give the tomato pest resistance, and we have given a cow a human gene that allows it to make a medication in its milk. Today, we call any plant or animal “transgenic” if it carries an added gene, whether the gene is from a different species, the same species, or is a synthetic gene that does not exist in nature. We call these added genes transgenes.

All transgenic plants or animals have one thing in common. Their genetic material, or genome, has been permanently changed through genetic engineering. These changes will be passed to future generations through normal reproduction.

Transgenic technology allows us to meet the traditional goals of breeding – giving plants or animals specific traits – more quickly and precisely. It also allows us to develop traits we could not develop through traditional breeding. This issue of Your World/Our World concentrates on the development of transgenic animals and some potential applications. The field of transgenic animals is very young and, as you will see, still has many hurdles to cross.

Ask Yourself:
As you read this issue, keep a log of your thoughts.
• How does transgenic technology continue the goals of traditional agriculture?
• How does it change these goals?

A. VIZSLA
B. POODLE
C. BEARDED COLLIE

These dogs have the same wolf ancestor. People tamed the wolf more than 12,000 years ago and have been developing new breeds ever since.

People have also bred new plant varieties. An ear of corn in the year 2,000 BC (left) was not nearly as hearty and nutritious as today’s corn (right).
These technicians are analyzing DNA tests on a computer to help farmers know which animals carry genes for desirable and undesirable traits. This information helps them select which animals to breed.

The Science of Breeding

Natural Selection and Selective Breeding

Even before people appeared on earth, the genes of animals were continually changing, evolving over thousands of years to form new species. Because the natural environment promoted these changes in species, we call this process of change “natural selection.” When people began to use animals as companions, workers, and sources of food, we began to promote changes in many species through “artificial selection” or “selective breeding.” We chose animals with valuable traits to breed in order to develop the traits we liked, generation after generation.

Genetic Science Unveils Hidden Causes of Traits

In the past, farmers decided which animals to breed based only on what they could observe, such as the amount of milk a cow made. The things we observe are “phenomena,” and so observable traits are called phenotypes. Today, we recognize that genes (interacting with the environment) are the basis for these observable traits. The specific genetic information that causes a trait is the genotype, or gene structure. Scien-

Career Tip: Farming

Farmers raise animals, feed them, keep them free of disease, and get their food products to market. It has always been a year-round job. Today, farmers must do even more than just work hard. They must be high-tech jacks-of-many-trades, with knowledge in the areas of chemistry, biotechnology, and finance. Look for related agricultural careers throughout this magazine.

This farmer talks with an agricultural consultant about his herd.
tists are identifying many genes in the DNA of different animals. As a result, we can now examine what happens at the genetic level when animals breed, including processes we could not observe or predict before. (You can explore this process in the activity on page 14.) Today, farmers can test their animals’ DNA to see whether they carry the genes for desirable or undesirable traits, thus taking the “guesswork” out of breeding. In fact, modern farmers are big customers for companies that test DNA.

**Custom-Made Genes**

Genetic engineering allows us to do more than just select animals to breed based on their genes. We can also change genes in very specific ways by using recombinant DNA technology. “Recombinant” comes from the word “recombine,” which is basically what we do to genes. We can “cut” a gene out of a strand of DNA, “copy” (clone) it, and “paste” (insert) it into another strand of DNA. In this way, we can construct custom-made genes, called transgenes, and insert them into an animal’s reproductive cells (egg or sperm). This ability to insert genes into reproductive cells is the key step in developing transgenic animals.
Microinjection: Inserting a Transgene into a Reproductive Cell

To develop a transgenic animal, scientists must insert a transgene into a reproductive cell (sperm or egg). The most common technique for doing this insertion is microinjection.

First, female animals receive a hormone that makes them release many eggs. These eggs are then fertilized and removed. A laboratory technician holds the fertilized eggs in place with a pipette under a microscope while injecting several hundred copies of a transgene into a pronucleus.

Ideally, the transgene will insert itself into a chromosome and will become a permanent part of the genome. (However, using current technology, only 1% to 3% of the fertilized eggs usually carry the transgene.) The fertilized eggs are then implanted in female animals, where they will develop into embryos.

If the transgene has become part of the genome, it will be present in every cell of the animal that develops, and it will be passed to following generations through regular sexual reproduction. In theory, the transgenic offspring will express the gene; that is, it will make the protein “encoded” by the gene. In early experiments, though, the transgenes were not always expressed.

To understand why they were not, we had to learn more about the structure of a gene, how it is regulated, and the right way to design a transgene.

Genzyme Corporation

Microinjection, magnified 250 times.

A laboratory technician holds a fertilized egg in place by a pipette while copies of a transgene are injected into a pronucleus.
Compare the rates at which pigs and cows can give birth to offspring. About how many litters can a pig have in one year? About how long would it take one cow to have as many offspring as a pig can have in one litter? Can you think of some reasons why many researchers use pigs instead of cows?

<table>
<thead>
<tr>
<th></th>
<th>PIGS</th>
<th>COWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestation period</td>
<td>4 months</td>
<td>9 months</td>
</tr>
<tr>
<td>Average number of offspring</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Time before mother can breed again</td>
<td>1 month</td>
<td>2.5-4 months</td>
</tr>
<tr>
<td>Age at which offspring can breed</td>
<td>6 months</td>
<td>1 year</td>
</tr>
</tbody>
</table>

**What’s in a Gene?**

The function of most genes is to produce or express a protein. Some proteins become part of a cell’s structure and others help regulate a cell’s processes. In making proteins, different parts of the gene perform different functions (see diagram). A coding section contains the instructions for making a particular protein. The regulatory sections control when and where the protein is made. One of the regulatory sections, the promoter, allows the gene to be turned on in a cell. Another regulatory part, called the super regulatory element, controls how many copies of the protein the gene makes (its “level of expression”). Still another regulatory part acts as the stop signal.

**Gene Expression**

An animal has many types of cells that form tissues such as skin, brain, and mammary glands, and each cell type makes a different combination of proteins. Every cell in an animal carries all the genes in its genome, but only a fraction of those genes are expressed in any one cell. Many genes have specific expression, meaning they are expressed only in certain types of cells or tissues. For example, the genes for milk proteins are expressed only in the cells of mammary glands.

Why are some genes expressed in one cell but not another? The answer lies in the nature of the proteins already contained in the nucleus of the cell. These nuclear proteins, called transcription factors, are required for the expression of genes. If the right transcription factors are present in the nucleus, the gene will be expressed. If these proteins are missing, the gene remains silent. For example, the cells of the mammary glands have the transcription factors that “turn on” the genes that produce milk proteins.

**Transgenes in Trouble**

In its natural form, every gene has a “home address,” a specific location on a certain chromosome. At its home address, the gene can be easily expressed. However, when a transgene is microinjected into an egg, it can go to another address or even to another chromosome. Such misdirected genes may or may not turn on, or they may make too little protein. That is why some transgenic animals do not express the protein the transgene is supposed to produce, or they express it at too low a level to be helpful.

**Designer Transgenes to the Rescue**

We can help ensure that transgenes will work at any address in the genome by combining the right tissue-specific promoters and super regulatory elements with the protein-coding sections of the gene. The “modular” structure of a transgene thus opens up many possibilities for expressing different proteins in different tissues. Depending on what we want the gene to do, we can mix and match the sections of DNA from different sources to create a designer transgene. You can read about some of these possibilities in the following articles.
Human Milk from a Cow!

When you were born, you did not have a lot of immunity – the ability to fight different diseases. If your mother breastfed you, you got a large dose of immunity from the proteins and antibodies in her milk. If you drank formula instead, you did not have the benefit of those proteins and antibodies. Formula, usually made from cow’s milk or soybeans, lacks some of these ingredients that are so good for newborn babies. One of these proteins, called human lactoferrin, helps prevent bacterial infections that cause digestive problems that harm or kill millions of newborns around the world. There is no efficient way to make human lactoferrin artificially. However, there may soon be a new “natural” source, thanks to our ability to construct a designer transgene for tissue-specific expression of a protein.

Since human lactoferrin is produced in the mammary glands, how do you think it could be produced in animals? If you answered, “In the mammary glands of other milk-producing mammals, like cows,” then you think like a genetic engineer!

Scientists first isolated the gene for human lactoferrin. Then they created a transgene by combining the protein-coding section of the lactoferrin gene with a regulatory sequence that is recognized by the cells of a cow’s mammary glands. Using microinjection, they put this transgene into fertilized cows’ eggs and implanted the eggs in foster mother cows. The first calf born with the human lactoferrin gene was a bull named Herman. Herman has now fathered many calves. About half of them are transgenic, and of those, the females are producing human lactoferrin in their milk!

One day, we may be able to add this lactoferrin to infant formula. Scientists still need to test this milk for effectiveness, and it will need to pass many food safety requirements. If successful, medical researchers expect to find additional uses for lactoferrin’s anti-bacterial activity. They even foresee using it to strengthen the immune systems of people with cancer, AIDS, and other health problems.

Herman, the first bull with the gene for human lactoferrin, lives with his calves in the Netherlands.
These scientists are developing a line of transgenic chickens that will be free of disease by giving them disease-resistant or disease-fighting genes.

**Low-Fat Meat, Disease-Free Animals**

Future transgenic developments may make both people and animals healthier. Some researchers are developing animals that can resist common diseases. Others are working to develop animals that convert more of their food to muscle and less to fat. If successful, these animals might give us leaner beef, leaner pork, and low-cholesterol eggs—foods that could help reduce many health problems in people.

**SuperFish**

Since fish are a source of plentiful and low-fat protein, many people are interested in increasing fish production as a way of feeding the world’s growing population. One way to increase fish production is to make fish grow faster and larger. In some experiments, scientists have given various fish the growth hormone gene from the fast-growing freshwater trout. These transgenic fish grow faster and larger than their natural cousins.

Other research focuses on increasing the conditions under which certain fish can live. Scientists have given salmon the Arctic flounder’s “antifreeze” gene that makes it possible to survive in cold temperatures. This antifreeze gene could allow the salmon to be raised in colder waters than its normal habitat.

These transgenic fish are part of a relatively new field of “aquaculture,” where commercial fish are raised in fenced-in fish farms (and will not be released into the wild). Can you guess where the word “aquaculture” comes from? **Genetic Engineering News**

**Better Cheese**

To make cheese, we mix milk with a protein called “rennin” which makes the milk curdle. Traditionally, rennin comes from the inside of a calf’s stomach, where it helps the calf digest milk. Biotechnology has already changed the art of cheese-making by developing a new source for rennin. Now, transgenics may further refine cheese-making by genetically engineering cows so they make milk that curdles more easily and consistently. This specialized milk could lower the price of cheese and give it a better quality.
A transgenic sheep named Tracy and her lambs produce a protein in their milk called Alpha-1-antitrypsin (AAT). This protein may help treat hereditary emphysema, a disease of the lungs that makes breathing so difficult that many people must use an oxygen tank to survive.

Across the North Sea from Herman the bull, Tracy grazes with her lambs in the Scottish highlands. On the other side of the Atlantic Ocean, a herd of goats romp in a field in Massachusetts. Like Herman’s calves, these animals are raised not for their traditional agricultural products (meat, milk, or wool), but for a specialized protein the females make in their milk. The goal of these experiments is to one day use these proteins to treat diseases in people. Because such transgenic animals produce medicines or “pharmaceuticals,” scientists have dubbed them “pharm” animals.

If the milk from transgenic cows, goats, and sheep contains medical proteins in the concentrations listed in the chart, how many of each animal would you need to make the needed quantity of these medicines?

<table>
<thead>
<tr>
<th>Animal</th>
<th>Protein</th>
<th>Milk production per animal*</th>
<th>Concentration*</th>
<th>Quantity needed</th>
<th>Number of animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td>lactoferrin</td>
<td>20 liters/day</td>
<td>1g/l</td>
<td>100kg/day</td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td>AT-III</td>
<td>1.5 liters/day</td>
<td>100mg/l</td>
<td>1kg/day</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>AAT</td>
<td>1 liter/day</td>
<td>10mg/l</td>
<td>100g/day</td>
<td></td>
</tr>
</tbody>
</table>

*NOTES: These are hypothetical quantities only. 1000mg=1g, 1000g=1kg; g=gram, mg=milligram, kg=kilogram

Hospitals use huge quantities of blood – 10 million pints a year in the U.S. Where does all this blood come from? You may have seen “blood donation drives” around town, where people donate some of their blood to be stored. In spite of these donors, it is difficult to keep enough blood stored for medical needs.

A New Source for Human Blood Proteins
If you have ever had a terrible cut, you know how much you can bleed. To keep people alive when they have lost a lot of blood, doctors give them transfusions. Hospitals always need blood for transfusions in operations and emergencies.

Are dogs “man’s best friend” – or might it be pigs? Pigs are biologically very similar to humans, and so they are the source of many life-saving medical products.
Now, some scientists are developing an alternative supply – a blood substitute made from hemoglobin, the complex protein in red blood cells that transports oxygen. One possible way is to use transgenic pigs that produce human hemoglobin in their own blood as blood donors. The hemoglobin could be purified from their blood and used to create a blood substitute to give to human patients. Because pigs are so easy to breed, they could provide an unlimited supply of inexpensive hemoglobin. This supply could help solve the problem of blood shortages.

**Transgenic Organ Transplants**

You may have heard news stories about children waiting for a liver or heart transplant. What makes their condition so sad is that they must wait for another, healthy person to die, usually from an accident or injury. Every year in the United States, more than 16,000 lives are saved by transplants, yet 3,000 people die (and countless more remain sick) while waiting for an organ.

How can we increase the supply of healthy organs? One way is to encourage more people to donate their organs. Some scientists are exploring another possibility — transplanting organs from transgenic pigs.

Pig organs are about the same size as human organs. We already use the valves from pigs' hearts for human heart valve transplants and pig skin for skin grafts for burn victims. But organ transplants are much more complicated than heart valves or skin grafts.

Normally, we could not use pigs' organs because our bodies would completely reject them. Non-human organs have foreign proteins that tell our bodies they are dangerous intruders. Our antibodies and immune cells immediately attack a foreign organ and destroy it. This immediate extreme reaction does not occur when human organs are transplanted because human organs have a protein that identifies them as human. (Human organs are rejected by a slower immune reaction which can often be overcome by drugs.) Scientists identified the gene for that human-friendly protein and developed transgenic pigs that express it in their organs. Theoretically, these organs will not be immediately rejected by the human immune system.

Overcoming this immediate rejection is just the first step towards cross-species organ transplants, called “xenotransplants.” (The prefix “xeno” means foreign.) Many other major technical problems must be resolved before pig organs can be used in transplants.

In its natural state, hemoglobin (the complex protein that carries oxygen in the blood) is contained within a cell. In blood substitutes, hemoglobin exists in solution rather than in a cell. Without an additional chemical - called a “cross-linker” - that hemoglobin complex could fall apart and would be toxic to the kidneys. Cross-linkers help hold the hemoglobin together in blood substitutes and prevent toxicity. In this model, the chemical cross-linker is the green and white threads in the center of the image.
Heart disease is a leading cause of death in the U.S. In fact, you probably know someone who is being treated for it. One common cause of heart disease is atherosclerosis, a thickening and hardening of the arteries (major blood vessels). In this condition, fat builds up inside the arteries, clogs them, reduces the flow of blood, and increases blood pressure. The person you know with this condition probably takes a medicine to help reduce these life-threatening problems. How do doctors know if the medicine works? If it is safe? What dose to use?

Before we start using medicine for people, we see how it works in animals with a similar disease. That way, we can study if the medicine is safe and how well it treats the disease. Since the beginning of the 1900s, scientists have used traditional breeding techniques to develop laboratory animals with the traits of certain human diseases. We call these specialized animals “models” of human disease. We use them to learn more about diseases, to find treatments or cures, and to test new medicines.

Transgenic technology allows us to create more specialized animal models, such as transgenic mice that have the disease atherosclerosis. These mice express two human proteins that cause an accumulation of cholesterol in their bloodstream. The mice eventually develop atherosclerosis and, like people, accumulate fat in their arteries. Using these mice, scientists can test medicines that lower cholesterol levels before giving them to people. These transgenic mice may lead to a better treatment for one of the biggest health problems in this country.

The transgenic mouse on the right is a model for atherosclerosis, a human disease that causes hardening and thickening of the arteries. The mouse on the left is a normal, healthy mouse. The views below show a magnified cross section of their arteries. A stain was used to show the fatty deposits, which appear red in the photo. The transgenic mouse has much more fat in the artery than the normal mouse. Scientists are using these transgenic mice to find new drugs to treat this common disease in people.

Ask Yourself:

Research several diseases for which vaccines or treatments are available (such as polio, diabetes, cancer, cystic fibrosis). Do any of these procedures rely on animal models? Was there an alternative to using animals for this research?
Our Long Relationship with Animals

We have many relationships with animals. They are our pets and our beasts of burden. We raise them for racing and for “showing,” and to test cosmetics, medicines and toxins. They have always provided us with meat, eggs, milk, wool, leather and fur, and more recently, medicines such as insulin. Now some people want them to produce new kinds of medicines as well as transplant organs. We have always bred animals for our benefit. Transgenic technology can fine-tune those benefits. Which of these uses can we justify—and why? All? None? Some?

Attitudes Towards Animals

Some people who study moral issues—questions of “right and wrong”—have defined three basic attitudes towards animals. Do your beliefs fit into any of these categories?

1) Animal Exploitation: Human needs are always higher than animals. Therefore, people can use animals any way we like.

2) Humane Use of Animals: We have to balance human needs and animal needs. While we can use animals for our benefit, we cannot abuse them. We can raise them for food and other products as long as we kill them painlessly, and we can do experiments on them if we do not cause them unnecessary suffering.

3) Animal Rights: Animals have the same moral status as people, and it is not right for us to use them for our own benefit. We should not more experiment on them than we should on people who cannot take care of themselves.

Animal Well-Being

Congress and other government agencies have passed strict regulations about the treatment of animals based on the principle that humans are responsible for the well-being of animals in our care. (This principle is an outgrowth of position #2 above.) For example, animals raised for medical experiments must not suffer unnecessarily and should have a natural lifestyle and freedom of movement. When researchers use animals, they must use the fewest number possible and the least painful procedures available.

Some animal rights advocates, however, want to prevent many uses of animals, including all medical experiments and transgenic research. Today, more and more researchers are doing their work using “non-animal models.”

Patenting Life

Some people are not opposed to transgenic research, but they object to the patenting of transgenic animals. A patent is a kind of temporary “ownership” of a technological invention, and it prevents others from copying the invention without permission and payment of a royalty (fee). Some people think it is immoral to patent transgenic animals because living creatures are not human creations or machines. On the other hand, developing transgenic animals is a very long and expensive process, and companies depend on future royalties to pay for this development. Without patents, many important advances in medicine and nutrition that could help millions of people worldwide might slow or stop.

Ask Yourself:

Has animal biotechnology redefined our relationship with animals? How is it different from what came before? How is it a continuation of the same goals? What standards should we follow for treating animals well? Should we have different standards for animals raised for agriculture and those used in medical experiments?
Notice that the chromosome pairs are similar in that they have the same genes, but they have different variants of each gene. The combination of these variations determines which traits will show.

Recessive traits appear only when two recessive genes are present; otherwise the dominant traits appear. Figure 2 shows the traits determined by the genes on the chromosome. Of course, this example is overly simplified; in reality, most traits are determined by the interaction of many genes and the environment.

In this activity, you will analyze the genotypes and phenotypes of these animals and their potential offspring. For example, if a male has these genes in Chromosome 1: Aa, Bb, and tt, he has dominant phenotypes for A and B, and a recessive phenotype for t. He will have a solid coat, brown eyes, and a curly tail.

**Directions**

1) Copy the chromosome strips in Figure 1 onto two separate sheets of paper. Copy the female's chromosomes onto white paper and the male's chromosomes onto colored paper.

2) Label four cups as follows: female 1, female 2, male 1, and male 2.

3) Cut the chromosomes into vertical strips and separate chromosome 1 from chromosome 2. Place them in their respective cups. (Note that you are separating the duplicated chromosomes from one another by cutting through the centromere, and you are also separating the related chromosome pairs from one another.)

4) Put the male cups together and the female cups together.

5) Randomly select one chromosome from each of the two male cups and place them together to create the “egg.” Now create the “sperm” by following the same procedure with the female chromosomes. (Note that the egg and sperm each contain only one of each of the chromosomes. The egg and sperm have half the total number of chromosomes as cells in the rest of the body.)

6) Put the chromosome strips that you selected together to represent the fertilized egg, which has one of each chromosome from both parents. Pair the chromosomes by whether they are a “1” or a “2.”

7) Analyze the genes from the two chromosomes and record each phenotype and genotype. Your teacher will show you how to organize a chart.

8) Put all the strips back into their respective cups and repeat this procedure again (starting with #5). Repeat it seven more times, recording the results for all eight trials on the chart.

**Discussion**

1) Do some offspring have blue eyes, when neither parent did?

2) Does the phenotype of the parents predict all the possible outcomes for the offspring? In other words, if both parents have brown eyes, will all their offspring have brown eyes?

3) We would expect these ratios for these phenotypes:

   - 3/8 of the offspring would be B_P_ (brown eyes and long horns).
   - 1/8 of the offspring would be bbP_ (blue eyes and long horns).
   - 3/8 of the offspring would be B_pp (brown eyes and short horns).
   - 1/8 of the offspring would be bbpp (blue eyes and short horns).

   How did the outcomes of your eight trials compare to the predicted outcomes?

   Note: Blanks (_) accompany dominant genes, since the dominant traits show no matter what the other gene is.

4) If you combine the results of all the trials in your entire class, do the numbers get closer to the predicted outcomes? Can you explain why or why not?

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**Background**

This exercise demonstrates the random separation and reassortment of chromosomes during sexual reproduction. This reshuffling of chromosomes creates variations in genetic material (genotypes) and observable traits (phenotypes) that we see among individuals in a species.

Figure 1 shows two pairs of chromosomes for both female and male during the creation of the egg and sperm. Each chromosome in each pair has duplicated; there are now two identical copies of each pair. The duplicated chromosomes are still held together by a structure called the “centromere” (the large dot).

The letters on the chromosomes represent genes. (The numbers are only for identification during your activity.) Each gene has two variations: a dominant variation (upper case letter “A”) and a recessive variation (lower case letter “a”).
Vernon G. Pursel grew up on a dairy farm in western Nevada, and he always knew he would devote his life to working with animals. As a young boy, he was active in the 4-H Club and Future Farmers of America, raising his own pigs and calves. He went to the University of Nevada to get a B.S. in Animal Husbandry, expecting to go into farming. His plans changed when, in his senior year, he became inspired by a laboratory research course in animal physiology. He went on to get a Ph.D. in Dairy Husbandry from the University of Minnesota and soon accepted a position as Research Physiologist with the U.S. Department of Agriculture’s Agricultural Research Service in Beltsville, Maryland. Almost thirty years later, Dr. Pursel has received many awards for his pioneering work in animal research.

Early in his career, Dr. Pursel helped develop a technique for preserving frozen semen for artificial insemination in pigs (in which the female egg is fertilized without mating). This technique allows farmers worldwide to improve the quality of their herds. This work led Dr. Pursel to genetic engineering and techniques for microinjecting transgenes into fertilized eggs. Microinjection was originally only possible with mice and rabbits, since their eggs are clear enough for the laboratory technician to see the pronuclei. The eggs of pigs and cows, however, are cloudy because they have a lot of fat. “Trying to find a pronucleus is like trying to see a golf ball in a glass of milk,” Dr. Pursel explained.

He and his team developed a method using a high-speed centrifuge, spinning the egg so the fat collects on one side, revealing the pronuclei that remain in the center. This method opened the door to transgenic research in pigs, cows, and other large mammals.

Once opened, the door led Dr. Pursel down several paths. One direction led to transgenic pigs that will produce antibodies against bacteria that cause pneumonia and digestive diseases. Another direction involved transgenic pigs that will produce a human protein to treat a rare genetic disease at a much lower cost than current treatments. Still another involved transgenic pigs that will have more lean meat and less fat. They have a transgene for a growth hormone that allows them to convert more of their feed to muscle rather than fat. Such pigs would not only produce healthier meat for human consumption, they would also require less feed and produce less waste.

All of these projects are still in development, and they all require extensive teamwork and many kinds of skills. “If one person drops the ball, everything goes down the drain,” Dr. Pursel commented. “The people that take care of our pigs are just as important to the success of our research as those of us that plan the experiments.”

Dr. Pursel has come a long way from his rural roots in Nevada, and his career has changed somewhat from his original goal. He still is devoted to working with animals, and he is happy that his work might produce something good for people worldwide.
Dear Students:

We are pleased to provide you with this issue of Your World/Our World. We hope you find it an interesting way to learn more about biotechnology. Biotechnology can be important to you for two reasons:

1. During your lifetime there will be tremendous discoveries in this field, and you'll want to understand what those discoveries mean for you, your friends, and your family.

2. You can help make those discoveries if you decide to continue to study science and math.

Either way, we hope you join us in discovering the promise of biotechnology for our world. We are pleased to acknowledge the support of the companies listed. Their support makes this magazine possible.

Sincerely,

Jeff Davidson
Executive Director
Pennsylvania Biotechnology Association

Read More About It!

Read More About It!
Your World/Our World:
Vol. 2, No. 1 (DNA profile)
Vol. 2, No. 2 (plant biotechnology; DNA transcription/translation)
Vol. 3, No. 1 (producing medicines through fermentation; rennin for cheese)
Vol. 3, No. 2 (vaccines and the immune system)
Vol. 4, No. 1 (development of drugs and patents)

Online References for AgBio Resources:
Global Agricultural Biotechnology Association:
http://www.lights.com/gaba/onlin.html
Biotechnology Information Center:
http://www.inform.umd.edu/EdRes/Topic/AgrEnvi/Biotech
Access Excellence:
http://www.gene.com:80/ae

Other Contacts:
Animal Welfare Information Center
National Agricultural Library
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Beltsville, MD 20805
Tel: 301-504-6212
Biotechnology Information Center
National Agricultural Library
10301 Baltimore Blvd.
Beltsville, MD 20895-2351
Tel: 301-504-5340
National Agricultural Biotechnology Council (NABC)
158 Biotechnology Bldg.
Cornell University
Ithaca, NY 14853
Tel: 607-254-4859

Correction to Vol. 4, #2, Gene Therapy, page 3 graphic: The middle circle in the illustration should have shown the chromosomes as separate strands, not as an X-shaped figure.

Preview of the Next Issue:
The Human Genome Project.
Don't miss it!

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