Alzheimer's Disease

- Alzheimer's Disease is the most common cause of dementia
- Alzheimer's accounts for 60 percent to 80 percent of dementia cases
- Alzheimer's is the 6th leading cause of death annually in the United States

Alzheimer's is a type of dementia that causes problems with memory, thinking, and behavior. Symptoms usually develop slowly and get worse over time, becoming severe enough to interfere with daily tasks. Microscopic changes in the brain begin long before the first signs of memory loss.

Scientists believe Alzheimer's Disease prevents parts of a cell's factory from running well. They are not sure where the trouble starts. But just like a real factory, backups and breakdowns in one system cause problems in other areas. As damage spreads, cells lose their ability to do their jobs and, eventually die, causing irreversible changes in the brain.

The brain has 100 billion nerve cells (neurons). Each nerve cell connects with many others to form communication networks. Groups of nerve cells have special jobs. Some are involved in thinking, learning, and remembering. Others help us see, hear, and smell. To do their work, brain cells operate like tiny factories. They receive supplies, generate energy, construct equipment, and get rid of waste. Cells also process and store information and communicate with other cells. Keeping everything running requires coordination as well as large amounts of fuel and oxygen.

Two abnormal structures called plaques and tangles are prime suspects in damaging and killing nerve cells.

1. **Plaques** are deposits of a protein fragment called beta-amyloid (BAY-tuh AM-uh-loyd) that build up in the spaces between nerve cells.

2. **Tangles** are twisted fibers of another protein called tau (rhymes with "wow") that build up inside cells.

Though autopsy studies show that most people develop some plaques and tangles as they age,

Image from National Institute on Aging, NIH

those with Alzheimer's tend to develop far more and in a predictable pattern, beginning in the areas important for memory before spreading to other regions.

Scientists do not know exactly what role plaques and tangles play in Alzheimer's disease. Most experts believe they somehow play a critical role in blocking communication among nerve cells and disrupting processes that cells need to survive. It's the destruction and death of nerve cells that causes memory failure, personality changes, problems carrying out daily activities and other symptoms of Alzheimer's disease.

A vital brain cell transport system collapses when a protein called tau twists into microscopic fibers called tangles, which are another common brain abnormality of Alzheimer's. Researchers are looking at a way to prevent tau from forming tangles.

Tau aggregation inhibitors and tau vaccines are currently being studied in clinical trials.

Growing evidence suggests that brain health is closely linked to heart and blood vessel health. The risk of developing Alzheimer's appears to increase as a result of many conditions that damage the heart or arteries. These include high blood pressure, heart disease, stroke, diabetes and high cholesterol. A number of studies in mice are exploring how best to build on this connection.

Despite many promising leads, new treatments for Alzheimer's are slow to emerge. Current Alzheimer's treatments temporarily improve symptoms of memory loss and problems with thinking and reasoning. Experts are cautiously hopeful about developing Alzheimer's treatments that can stop or significantly delay the progression of Alzheimer's. A growing understanding of how the disease disrupts the brain has led to potential Alzheimer's treatments that short-circuit basic disease processes.

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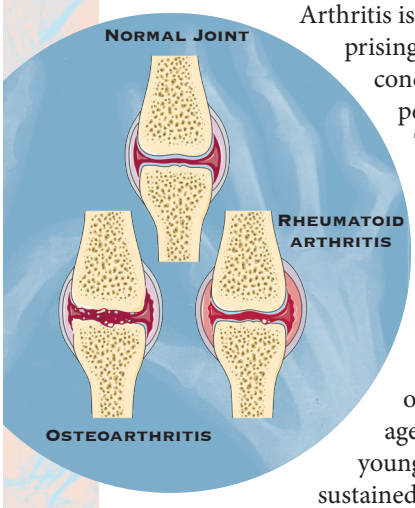
Arthritis

- With 1 in 3 Americans effected, Arthritis is the leading cause of disability in the U.S.
- More than 70 million Americans are afflicted with some form of arthritis
- There is no known cure for arthritis, but advances in science are helping us to identify ways to improve diagnosis and its treatment



Arthritis is a complex disorder comprising more than 100 distinct conditions and affecting people at any stage of life. Two of the most common forms are osteoarthritis (OA) and rheumatoid arthritis (RA).

Osteoarthritis is the most common form of arthritis. The disease often develops as a person ages, but can occur in younger adults due to injuries sustained in sports or accidents. Osteoarthritis is a condition where the cartilage covering the bone ends wears away. In a healthy joint, the cartilage covers the ends of the bones within the joint, allowing the bones to glide smoothly over one another. The cartilage acts as a shock absorber for the joints during physical activities.

Rheumatoid arthritis is a chronic disease, mainly characterized by inflammation of the lining, or synovium, of the joints. It can lead to long-term joint damage, resulting in chronic pain, loss of function, and disability. Scientists have yet to find an exact cause for rheumatoid arthritis, but they do know that the body's immune system plays an important role. In a healthy immune system, white blood cells produce antibodies that protect the body against foreign substances. People with rheumatoid arthritis have an immune system that mistakes the body's healthy tissue for a foreign invader and attacks it.

Since the causes of most forms of arthritis are not known, doctors attempt to treat the symptoms. Treatment options vary based on the form of arthritis. They can include physical and occupational therapy, medications for inflammation, pain, and infection, and occasionally, prosthetic joint replacement. Through additional research, especially research in animal models with forms of arthritis, researchers are working toward an

understanding of the root causes of arthritis. This critical knowledge is the key to designing better and more effective methods of diagnosing, treating, and even preventing arthritis related diseases.

Thanks to genetics research, many new drugs to treat RA have come online in the past 15 years. Before then, disease-modifying antirheumatic drugs were man-made. Most of the newest drugs are biologics, meaning they're made from human genes. These potent copycats may stop an overactive immune system.

Because these drugs target specific steps in the inflammation process, they don't wipe out your entire immune system, as some other RA treatments do. For many people, a biologic drug can slow, modify, or stop the disease—even when other treatments haven't helped much.

The first of a new kind of drugs, Jakinibs or JAK inhibitors, was approved in 2012. Sometimes called an "oral biologic," this medicine is available as a pill rather than as a shot or an infusion, as with the other biologics. Jakinibs work from inside the cells to block the enzymes that alert the immune system to an invader.

Significantly, future research into the causes of arthritis will utilize mice to look at how four factors work alone and together to produce the disease. The four factors include how the body contributes to the disease process and the roles heredity, infections, and the environment play.

With this information, scientists may be able to correct malfunctions in the immune system by immunizing people against bacteria or viruses that trigger some forms of arthritis. Researchers may be able to prevent types of arthritis from ever happening by identifying and eliminating those factors that cause them. One of the biggest areas of future research will concern genes and gene replacement. Some forms of arthritis probably result from genes that have the wrong set of instructions.

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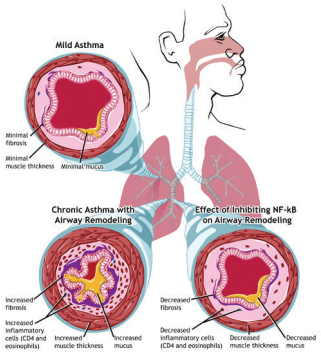
Asthma

- Asthma affects almost 25 million Americans; nearly 10 million children
- One in four urban children in the U.S. has asthma
- Annually, treatment of asthma costs billions of dollars in the U.S.
- More boys have asthma than girls, but in adulthood, more women have asthma than men



Asthma is a chronic disease of the respiratory system where the airways (bronchi) constrict, become inflamed, and are lined with excessive amounts of mucus. The muscles around the airways also tighten, making the airways even narrower. This airway narrowing results in symptoms such as wheezing, shortness of breath, chest tightness, coughing, and difficulty in breathing.

In some people, asthma is a chronic respiratory impairment. In others, it occurs only occasional or episodically with symptoms resulting from a triggering event, like an upper respiratory infection, airborne allergens, or exercise. Whenever an asthma episode is severe, a person may require emergency treatment to restore normal breathing. Without proper medical attention, a person may die of an asthma attack.

There are two types of asthma, allergic and non-allergic. Allergic asthma is the most common form of asthma. Allergic asthma is triggered by inhaling allergens such as dust mites, mold, pet dander, or pollens. Non-allergic asthma is triggered by factors not related to allergies such as anxiety, stress, exercise, medications, cold air, dry air, hyperventilation, or smoke and other irritants. In non-allergic asthma, the immune system is not involved in the reaction.

Asthma research helps us understand how the disease is caused, how it develops, and how it is best treated. Research can improve the quality of everyday life for those diagnosed with asthma. Researchers have been unable find a cure for asthma, nor have they been able to fully determine what makes the airways of people with asthma become inflamed. Research has shown that asthma runs in families and that a person is more likely to be diagnosed with asthma if

National Institute of Allergy and Infectious Diseases, National Institutes of Health

another person in the family is an asthmatic. Additional research has shown that exposure to tobacco smoke and other air irritants, infections, and certain allergens early in life may increase a person's likelihood of developing asthma. Obesity has also been linked to causing asthma. Targeted research to understand the underlying immune responses that lead to asthma is also being conducted. This understanding may aid the development of asthma prevention strategies and treatments to improve life for those already living with the disease.

Study of animal diseases that are similar to asthma have helped scientists understand how certain cells entering the lungs during an attack release chemicals that then act on the nerves, muscles, and mucus-secreting cells, causing airway inflammation. Research involving rabbits and guinea pigs has also helped scientists to successfully develop various medications and treatments, including fast acting treatments for use during an asthma attack such as broncho-dilators delivered through inhalers, and newer preventative medications that can potentially prevent an asthma attack from occurring. Such research and the resulting treatments have made it possible for many people to control their asthma, treat attacks and restore breathing, prevent asthma attacks, and all in all lead active lives. As research continues, scientists work toward a fuller understanding of how and why asthma occurs, and then subsequently, toward discovering a cure.

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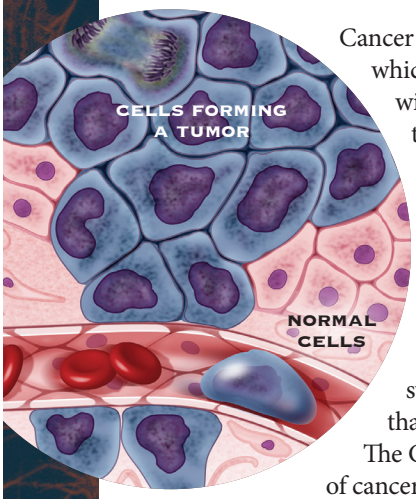
Cancer

- One out of every four deaths in the U.S. is due to cancer, making it the second leading cause of death among Americans. Cancer is among the leading causes of death worldwide.
- Approximately one-third of the men and women in the U.S. will be diagnosed with cancer in their lifetime.



Cancer is a term for diseases in which abnormal cells divide without control, often with the ability of these cells to invade other tissues in a process called metastasis, either by direct growth into adjacent tissue or by implantation into distant sites through the bloodstream or lymphatic system. There are more than 100 forms of cancer. The CDC expects the kinds of cancer to increase the most are Melanoma (the deadliest kind of skin cancer) in white men and women; Prostate, kidney, liver, and bladder cancers in men; and lung, breast, uterine, and thyroid cancers in women.

Although cells in different parts of the body may look and work differently, most repair and reproduce themselves in the same way. Normally, this division of cells takes place in an orderly and controlled manner. If, for some reason, the process gets out of control, the cells will continue to divide, developing into a lump that is called a tumor. Not all cancers form a solid mass. For example, leukemias are specific cancers of the blood that do not form a traditional "tumor" in the body.

In a benign tumor, the cells do not metastasize, but they can still be serious or fatal. If they continue to grow at the original site, they may cause a problem by pressing on the surrounding organs. A malignant tumor consists of cancer cells that have the ability to spread beyond the original site. If the tumor is left untreated, it may invade and destroy surrounding tissue. Sometimes cells break away from the original (primary) cancer and spread to other organs in the body along the bloodstream or lymphatic system.

Cancer researchers believe that cancer can be triggered by many factors, such as genetics, diet, lifestyle, occupation and environmental factors. Cancer is treated though surgery to remove the affected cells, chemotherapy and radiation

Darryl Leja, National Human Genome Research Institute, NIH

therapy, and an extensive variety of medications. The approach to treatment is based on the type of cancer, location, and the progression of the disease. A number of experimental cancer treatments are also under development.

Scientists work with animals to investigate the causes of cancer, test new treatments, search for and work with new screening and diagnostic tools, and conduct molecular studies that may have a link to cancer. Researchers nearly always conduct the initial studies with rats and mice.

Many anti-cancer drugs are toxic to normal cells as well as cancer cells and can have toxic side effects. For this reason, scientists must test them on higher-order animals, such as dogs, ferrets, or rabbits, before human patients take the new drug or before drugs can be administered to pets or livestock. If the drug may cause a particular side effect in humans, the researcher picks an animal species to best model that possible side effect. Since almost all animals develop one form of cancer or another under normal conditions, this research is proving important to veterinary care. Domestic pets and wildlife have all benefited from current understandings and treatment of various forms of cancer.

More recent efforts in cancer research have focused less on drugs that are toxic to cancer (and normal) cells, and have focused more on secondary effects, such as immunotherapeutic drugs and vaccines that boost the immune system to fight cancer cells, hormone therapy that stops growth of the tumor cells, or genetic approaches that target specific genes that are active only in cancer cells. Research on the role of genes in both animal and human cancers have revolutionized the way we look at treatments for specific cancers. Since cancer includes an entire variety of diseases, it is unlikely that researchers will discover a single cure for cancer, but advances in each area of cancer research are important to advancing the general understanding of cancer, the body's reaction to cancer, and the development of a broad variety of treatments, preventative mechanisms, and cures.

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Companion Animal Diseases

- Dogs can die within 48 to 72 hours from canine parvovirus without treatment
- About 10% of the dogs that contract canine parvovirus die
- Feline leukemia virus is responsible for more deaths among cats than any other infectious feline disease
- Male cats are 1.5 times more likely to be infected with feline leukemia than females

Scientists are extremely interested in companion animal diseases. In addition to improving the quality of life for pets, studying companion animal diseases allows researchers to anticipate unusual occurrences of diseases that are transmitted from animals to humans. This research process assists in developing vaccines, and in designing treatment methods.

There are three types of feline leukemia virus and each particular type causes a different type of disease. Feline leukemia virus is spread through infected saliva, urine, tears, feces, and through an infected mother to her kittens during gestation and nursing. FeLV cannot be spread to humans since it is a retrovirus. A retrovirus is species-specific and is made up of RNA. In addition, retroviruses are fragile and can be inactivated by ultraviolet light, heat, and detergents. In addition to causing cancer and tumor growth in cats, FeLV can cause severe anemia and impact the immune system so the cat's ability to protect itself against other bacteria, viruses, and fungi that are found in the everyday environment. The same these secondary infections are responsible for many of the diseases and ill health associated with FeLV.

Lyme disease, a bacterial infection carried by ticks, is found in many regions of the U.S. It can infect dogs, cats and horses. Since it is a zoonotic disease, it can also be transmitted to humans. Lyme disease can cause fever, lameness, swollen joints, and other symptoms among animals. Infected humans may get a red, blotchy rash, fever, headache, and aching muscles and joints. Some may develop complications including disorders of the heart and nervous system. Most animals and humans treated with antibiotics will recover quickly. An effective vaccine has not been found.

Companion Animal Diseases— continued

Canine parvovirus (CPV) is a highly contagious virus that affects dogs. The disease, which did not exist prior to 1976, is spread from dog to dog through physical contact with feces. There are two forms of canine parvovirus: intestinal and cardiac. The cardiac form is rare and affects puppies less than eight weeks old by attacking the heart muscle causing heart failure in the dog. More than 80% of the dogs that are infected with canine parvovirus will not show any symptoms. Dogs that go onto to develop the disease show symptoms within 7 to 10 days. The symptoms are lethargy, vomiting, and diarrhea (usually bloody). Although there is no cure, dogs usually recover from the viral infection and associated symptoms within five days. Diarrhea and vomiting lead to dehydration and subsequently secondary infections can set in, causing death even in treated dogs.

The same methods that have been developed to prevent and treat diseases in humans have also been utilized to improve the lives of countless animals. Laboratory studies involving animals has been critical in developing veterinary techniques and pharmaceuticals such as the vaccines that fight such animal diseases as rabies, distemper, feline leukemia, infectious hepatitis virus, tetanus, heartworm, therapies for cholera in hogs, preventive techniques for tuberculosis in cattle, and influenza and encephalitis in horses. More than 80 medicines, vaccines, and medical devices and surgical techniques developed for humans are now used to heal pets, farm animals, and wildlife. In addition, treatments initially developed for humans such as treatment for cancer and heart disease, including pacemakers, antibiotics for infection, artificial joints for dogs, and treatments for toxoplasmosis are commonly used in veterinary medicine today. Significantly, research in reproductive physiology and artificial insemination with animals has helped save certain species from possible extinction, like the African wild cat, the California condor, the tamarins of Brazil, and the panda bear. It has significantly contributed to programs of wildlife-managed breeding in tigers, elephants, and other threatened species.

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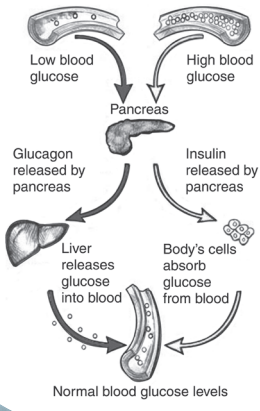
Diabetes

According to the CDC's National Diabetes Statistics Report for 2020: Estimates of Diabetes and Its Burden in the United States:

- 34.2 million people of all ages, or 10.5% of the U.S. population, have diabetes.
- 210,000 children and adolescents younger than age 20 years—or 25 per 10,000 U.S. youths—have diagnosed diabetes (includes 187,000 with type 1 diabetes).
- Diabetes was the 7th leading cause of death in the U.S. in 2017.

Diabetes is a metabolic disease in which the body has trouble regulating its blood glucose or blood sugar levels. Glucose is created when your body breaks down food to use for energy. Your body uses glucose as its main source of fuel with the help of a hormone called insulin. Insulin is produced and secreted by beta cells that are grouped in small islands called the islets of Langerhans found in the pancreas, an organ near your stomach. Insulin acts like a key to unlock the body's cells so that glucose can enter and provide essential energy for the body's cells and tissues. Insulin also helps your liver store extra glucose as glycogen that can be released back into the bloodstream whenever blood glucose levels drop. When you have diabetes, your body either makes little to no insulin (type 1 diabetes), or your body can't use its own insulin properly to stimulate cells to take up glucose (type 2 diabetes).



Type 1 vs. Type 2 Diabetes

Type 1 diabetes (formerly referred to as juvenile diabetes) occurs when your body's own immune system destroys pancreatic beta cells, the only cells in the body that make insulin, so sugar stays in the blood and builds up, starving cells and tissues. Type 1 diabetes usually occurs in children and young adults, and risk factors include autoimmune, genetic or environmental causes. People with type 1 diabetes require daily injections of insulin. Left untreated, type 1 diabetes can lead to very serious medical problems, including blindness, kidney failure, nerve damage, limb amputations, difficulty healing, cardiovascular disease, and premature death. There is no cure, and type 1 diabetics are dependent upon insulin therapy throughout their lives.

National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health

Type 2 diabetes is the most common form of diabetes. It is characterized by insulin resistance and is believed to involve a defect in the insulin receptor. Type 2 diabetes develops most often in middle-aged adults. Today, more and more children and young adults are developing type 2 diabetes at an alarming rate, probably due to the rise in childhood obesity. In addition to age and obesity, risk factors can include a family history of diabetes, development of diabetes during pregnancy (referred to as gestational diabetes), impaired glucose metabolism, lack of physical activity, and race/ethnicity. There is no cure for type 2 diabetes, but it can be managed.

Current therapies for type 1 diabetes include injectable insulin, implantable insulin pumps, and islet cell transplants. Today, a wide range of computerized glucose meters and implantable insulin pumps are capable of continuously sampling and analyzing blood glucose levels, as well as making automatic adjustments in insulin dosages delivered by the pump. Type 2 diabetes can be managed by following a healthy meal plan and a program of regular physical activity, losing weight, and taking medications like Metformin that help regulate blood glucose levels. Some type 2 diabetics may need to be on an injectable insulin at later stages.

Animal models have contributed significantly to the study of diabetes. Dogs were instrumental in our initial understanding of the etiology of diabetes. Mice have played a pivotal role in the discovery and development of drugs that restore normal blood sugar levels, preventing and reversing complications, and understanding the genetic basis for diabetes. Rabbits have been used to study the pathophysiology of diabetic diseases of the eye and provide insight into drugs to prevent or reverse this from occuring. Surgical research conducted in several laboratory species has led to pancreatic transplants, transplantation of beta cells, and the development of an artificial pancreas. Medical devices tested in laboratory animals have led to needle-free insulin injection systems, external and implantable insulin pumps, and continuous glucose monitoring devices.

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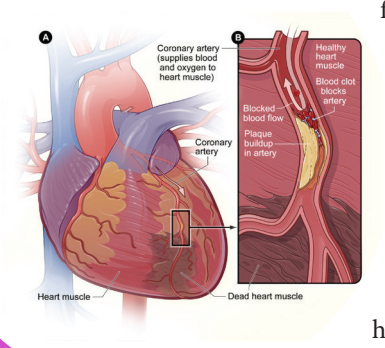
Heart Disease

- Heart disease is the number one cause of death annually in the United States.
- Nearly 3/4 million Americans experience a "myocardial infarction" (heart attack) each year.



Heart disease is any disorder that affects the heart's ability to function normally. Some heart diseases can be present at birth (congenital heart diseases), others develop as we age, and others can be caused by lifestyle. The term "heart disease" can include any of the following: coronary artery disease, ischemic heart disease, malfunction of heart valves and heart failure.

Cardiovascular disease is a general class of diseases that involve the heart and/or blood vessels (arteries and veins).

Coronary artery disease is the most common form of heart disease. Coronary arteries are the arteries that supply the myocardium which is the muscular layer of the heart. Coronary artery disease is the result of the degenerative accumulation of lipid-containing material within the walls of those blood vessels creating plaques. As the plaques grow and obstruct more than 70 percent of the diameter of the artery, the patient progresses to ischemic heart disease.

Ischemic heart disease is characterized by reduced blood supply to the heart. The symptoms of ischemic heart disease are often first noticed when extra work is placed on the heart, like during exercise. Symptoms include fatigue, breathlessness or rhythm disturbances.

Heart valve malfunction may be caused by congenital abnormalities, aging or infections. The valves of the heart open and close to move the blood forward when the heart is pumping. Poor function of a valve can result in either blood leaking backward (regurgitation) or restriction of forward blood movement (stenosis). Both conditions can occur at the same time. Heart valve disease can lead to heart failure.

As we age, humans lose some blood pumping ability in our heart, but the more serious reduction called heart failure, results from conditions that either damage the heart or make it work too hard.

National Heart, Lung and Blood Institute, National Institutes of Health

Heart Disease—continued

Many health conditions that you probably already associate with heart disease—such as high blood pressure, smoking, being overweight, eating foods high in fat and cholesterol, not exercising, and diabetes—can also cause heart failure.

Less commonly, heart failure has absolutely nothing to do with lifestyle. For instance, some people who develop heart failure were born with structural heart defects, while in others a virus damaged the heart muscle.

Animal research involving pigs, dogs, sheep and mice has been and continues to be extremely important in developing and improving devices (pacemakers, replacement heart valves), new surgical methods and drugs to treat and prevent heart disease or improve heart function. For example: knowledge about abnormal electrocardiographic (ECG) patterns associated with heart attack, as well as how to use an ECG to diagnose myocardial infarction, were derived from experiments on the dog heart. Dog studies also contributed to the development of the implantable pacemaker and defibrillator which have given countless patients hope for survival.

Cardiac surgery, including coronary by-pass operations were rare and risky prior to 1960. New interventions and support equipment were perfected in part due to animal research. In addition, the critical development and refinement of heart transplantation and the necessary associated immunosuppressive and beta-blocking drugs were developed and improved though laboratory studies of animals and their cardiovascular systems.

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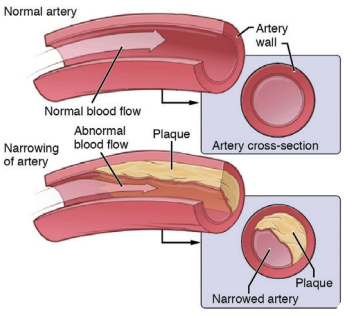
Hypertension

- Nearly half of adults in the United States (108 million, or 45%) have hypertension
- Only about 1 in 4 adults (24%) with hypertension have their condition under control
- Having hypertension puts you at risk for heart disease and stroke, which are leading causes of death in the United States
- Untreated, hypertension can affect all organ systems and can shorten one's life expectancy by 10 to 20 years



Blood pressure is the force in the arteries when the heart beats (systolic pressure) and when the heart is at rest (diastolic pressure). Physicians define Stage 1 hypertension as a systolic blood pressure from 130–139 mmHg or diastolic blood pressure from 80–89 mmHg, and Stage 2 hypertension as systolic blood pressure above 140 mmHg or diastolic blood pressure of 90mmHg or higher. Blood pressure is measured in millimeters of mercury (mmHg).

Hypertension is often called a "silent killer" because there are typically no symptoms of the disease. High blood pressure increases the workload of your heart and arteries. Your heart must pump harder to overcome the elevated pressure, and the arteries must carry blood that is moving under greater pressure. If high blood pressure continues for an extended amount of time, your heart and arteries may be damaged and not work as well as they should. Other body organs are also affected. Chronic hypertension is one of the leading risk factors for strokes, heart attacks, heart failure, and arterial aneurysm, and is a leading cause of chronic renal failure.

There are two forms of hypertension, primary (essential) and secondary. Essential hypertension accounts for 90–95% of all hypertension cases. Multiple factors and conditions may play a role in its development, including genetics, obesity, lack of physical activity, excessive salt or alcohol consumption, age, and stress. Although genetic factors are thought to play a prominent role in the development of essential hypertension, no one gene for hypertension has been identified.

OpenStax College

Hypertension—continued

In secondary hypertension, the high blood pressure is secondary to (caused by) an abnormality in another part of the body. Some causes include kidney disease, endocrine conditions, blood vessel abnormalities and some medications. Doctors can often alleviate secondary hypertension by treating the underlying disease condition. For example, doctors can repair a narrowed artery that supplies blood to a kidney.

Animal models are essential to our understanding of hypertension and its treatment. Some of the most influential are the spontaneously hypertensive rat models. There are several strains of rats which develop elevated blood pressure and related hypertension traits naturally, such at the SHR (spontaneously hypertensive rat) and DSS (Dahl salt sensitive) rat. Rat models have been used to study the relationship between stroke and hypertension, renal function, autonomic control of blood pressure, genetic components of hypertension and role of salt in the diet.

Transgenic techniques have been used to create hypertensive models in mice and rats. This method can help elucidate the role(s) a gene plays in hypertension by targeting specific genes for stimulation or suppression and looking for effects on blood pressure.

Hypertension can also be induced in large animal models, such as pigs or primates, by surgically reducing blood flow to the kidneys. This classic model, the Goldblatt kidney, is used to study the renin-angiotensin-aldosterone system (RAAS), investigate target organ injury and develop therapeutic interventions.

Animal models of obesity are also used to study hypertension due the close correlation between these conditions. The most common are mouse and rat models of spontaneous obesity, such as the obese Zucker rat and ob/ob mouse. These animals are either spontaneously hypertensive or hypertension can be induced by diet or chemicals.

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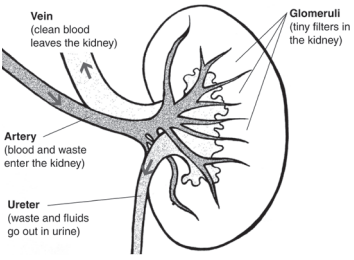
Kidney Disease

- 20 million Americans—1 in 9 U.S. adults—
  have chronic kidney disease, and another 20 million more are at increased risk
- Diabetes and high blood pressure are responsible for two-thirds of the cases of chronic kidney disease
- Kidney disease results from conditions that damage the kidney and decrease its ability to function properly



The kidneys are two bean-shaped organs, each about the size of a fist, located at the back of your upper abdomen on either side of your spine. The primary function of the kidneys is to filter water, salts, and waste products out of the blood to make urine. Kidneys also regulate blood pressure, balance chemicals like sodium and potassium, make hormones to help bones grow, and keep the blood healthy by making new red blood cells. When the kidneys lose their filtering ability, dangerous levels of fluid and waste can accumulate in the body.

Kidney failure may be acute or chronic. Acute kidney diseases is reversible and usually results from an injury or from poisoning. Any injury that results in loss of blood may reduce kidney function temporarily, but once the blood supply is replenished, the kidneys usually return to normal. Although acute kidney disease may have long-term consequences, it usually lasts for only a short period of time and goes away once the underlying cause has been treated. Kidney diseases include sudden loss or declining renal function, kidney stones, and cancer, among others. Many conditions causing renal failure are symptoms of other more systemic disorders like lupus, infections, or hypertension.

Chronic kidney diseases are irreversible and tend to worsen over time. The two main causes of chronic kidney disease are diabetes and high blood pressure. When blood sugar levels are too high the kidney can be damaged. High blood pressure makes the heart work harder and, over time, can damage blood vessels throughout the body. If the blood vessels in the kidneys are damaged, they may stop removing waste and extra fluid from the blood. The extra fluid may then raise blood pressure even more when kidneys stop working.

Image from Centers for Disease Control (CDC) Public Health Image Library

Kidney Disease—continued

The first successful organ transplant was a kidney transplant in 1952 between identical twins, thus eliminating problems of an immune reaction. It was not until 1964 with the development of medications to prevent and treat acute organ rejection through studies with mice, that kidneys were used from deceased donors. Researchers relied on animal studies to develop and perfect not only kidney, but also other organ transplantation and to develop the required medication to prevent organ rejection. As a result such transplantation techniques are also used in veterinary practices as well.

As late as the 1960's, end-stage kidney disease was a death sentence to everyone and still is in many countries. In the U.S. today, medical advances has prolonged the lives of patients with no kidney function. Kidney dialysis is one such advance. Using dialysis machines, a direct result of work on rabbits and dogs, the blood is filtered, removing waste products and extra water from patients, in much the same way a functioning kidney would. In addition, research in rats has led to new developments that even delay the need for dialysis or kidney transplants. Sheep have led researchers to perfect a shunt implant, a device that allows patients with kidney failure to be more comfortably connected to dialysis machines each time they must have treatment. Dialysis, however, does not cure any kidney disease, it is only a life support treatment. It is time-consuming process that patients must receive to stay alive. While patients feel better after treatment, as the toxins build back up in their blood they worsen until the next session of dialysis.

Animal models have been extensively used to clarify the pathogenesis and underlying mechanisms of kidney disease. Among these models, mice and rats are the most commonly used to study nephropathy events and potential therapeutic targets and to identify specific biomarkers of disease. Researchers are currently working on a new medical device that patients could have with them at all times as a form of constant dialysis. This would provide a more consistent level of care for patients, and reduce the need for multiply visits to dialysis centers throughout the week for care and treatment.

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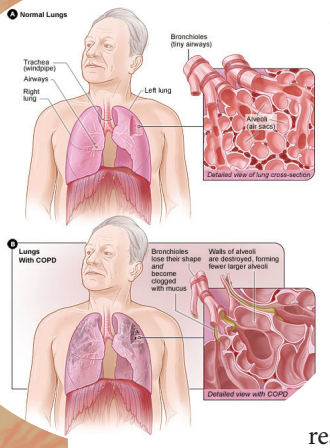
Lung Disease

- Lung disease is responsible for one in seven deaths in the U.S.
- More than 37 million Americans are living with chronic lung disease such as asthma, emphysema, and chronic bronchitis
- Lung disease and other breathing problems is the number one cause of death in infants younger than one year old



There are three main areas of lung disease: Airway diseases; Lung tissue diseases; and Lung circulation diseases . Many lung diseases involve a combination of these three types. Some are associated with other diseases or conditions, such as cystic fibrosis, while others fall under the category of Chronic obstructive pulmonary disease (COPD), a group of respiratory tract diseases characterized by partially blocked airways, making it difficult to get air in and out. Typically, these diseases are caused by exposure to airway irritants like coal dust, smoke, or solvents. They may arise due to congenital defects.

Although they are internal organs, the lungs are unique in that they are constantly exposed to our external environment—a direct interface with the world outside. With each breath, a host of alien substances enter our bodies—pollens, dust, viruses, bacteria; the constituents of the air in our homes and offices, factories, and workplaces, ranging from animal dander and tobacco smoke to radon and airborne lead; and the toxic chemicals released into our atmosphere by smokestacks and tailpipes. The lungs must play multiple roles—supplier of oxygen, remover of wastes and toxins, and defender against hostile intruders.

COPD is a progressive disease. Early symptoms include shortness of breath when active, frequent respiratory infections, and a morning cough. As the disease progresses, the symptoms increase in frequency and severity. In the late stages, the patient often experiences severe cough, constant wheezing, and shortness of breath with minimal exertion or rest. COPD is not curable. Medicines are often used to control symptoms or to reverse acute exacerbations.

Bronchiectasis is a chronic inflammatory or degenerative condition of one or more bronchi

National Heart, Lung and Blood Institute, National Institutes of Health

or bronchioles of the lungs marked by dilatation and loss of elasticity of the walls. Infection is the mechanism by which the disease progresses. The more the lungs experience infections, the more lung tissue and alveoli are damaged, and the more inelastic and dilated the bronchial tubes become, perpetuating the cycle of the disease.

Emphysema is a chronic disease that affects the alveoli and/or the end of the smallest bronchi. The lung loses its elasticity and these areas of the lungs become enlarged, trapping air and not effectively exchanging with fresh air. In asthma, inflammation makes the airways very sensitive, and they tend to react strongly, getting narrower, and allowing less air to flow through to the lung tissue. In a severe asthma attack, the airways can close so much that not enough oxygen gets to vital organs, resulting in death if not quickly treated.

Researchers are studying the many conditions that result from COPD as well as the causes of the diseases. Animal models have, and continue to provide insight into the mechanisms of lung disease, and new techniques for treatment of lung disease are facilitated through such research.

Rodents have been significant in studies of the effects of inhaling airborne particles and the toxicity of chemicals in lung diseases. Scientists working with laboratory mice are also making progress in their efforts to find a gene therapy for cystic fibrosis, and animal models are being studied to devise new ways of controlling asthma and AIDS-related pneumonia. Studies of emphysema in rabbits and horses - the only species besides humans to develop emphysema spontaneously– have helped researchers understand the stages of development of this disease, and are important in developing new techniques for treatment and prevention. Animal research remains essential to control and prevent human and animal suffering from lung ailments.

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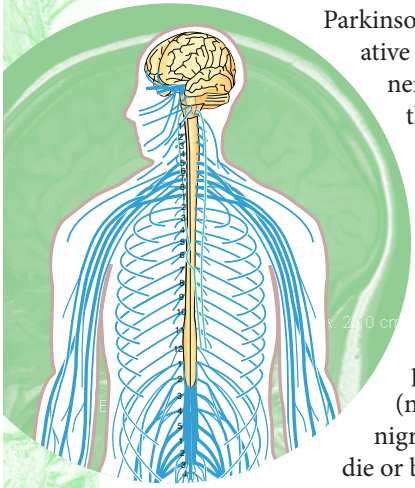
Parkinson's Disease

- As many as one million Americans and 10 million people worldwide are living with Parkinson's disease (PD). Approximately 60,000 new cases of PD are diagnosed each year in the United States
- After Alzheimer's disease, PD is the second most common neurodegenerative disorder
- Parkinson's disease affects both men and women, though several studies have found an increased incidence in men



Parkinson's Disease is a degenerative disorder of the central nervous system that affects the control of muscles, and so may affect movement, speech and posture. 50–80% of PD patients also develop dementia later in disease progression. The disease results when dopamine producing nerve cells (neurons) in the substantia nigra, a part of the midbrain, die or become impaired.

In the brain, two chemical messengers, dopamine and acetylcholine, work together to transmit messages between nerve cells and muscles. The messages enable us to perform a range of smooth, coordinated movements. For reasons still being researched, in Parkinson's patients the dopamine producing neurons die. When 80% of the dopamine-producing cells in the brain are depleted, symptoms of Parkinson's disease develop. Notable symptoms include muscle rigidity, tremor, a slowing of physical movement, and loss of balance. Additional symptoms include sleep disorders, slurred speech, loss of smell, a drop in blood pressure (orthostatic hypotension), double vision, cognitive impairment, dementia, and hallucinations. The level of dopamine continues to fall slowly over many years and symptoms worsen, at a rate which varies between individuals.

Researchers do not know what causes the loss of dopamine producing cells in the brains of people with Parkinson's. Many researchers believe many factors play a role in causing Parkinson's. Areas of research into the cause include genetics, environmental factors, Lewy bodies, and viruses. Scientists are also studying links between PD and the gut microbiome. In addition certain toxins, head trauma, and drugs can induce Parkinson's disease. There is no cure for Parkinson's, but

there are many drug treatments available to help control the symptoms and maintain quality of life. Dopamine replacements (levodopa), dopamine agonists, and deep brain stimulation are a few of the well-known treatment options currently available to patients.

Stem cells have the remarkable potential to develop into many different cell types in the body. Serving as a sort of repair system for the body, they can theoretically divide without limit to replenish other cells as long as the person or animal is still alive. When a stem cell divides, each new cell has the potential to either remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell. Stem cell-based treatments (using embryonic or pluripotent stem cells) are a promising future treatment for PD patients and could potentially allow cell regeneration. Research for these treatments is ongoing.

Research with new and repurposed drugs has led to clinical trials. Some drugs are targeting the clumping of the alpha-synuclein protein, a hallmark of Parkinson's and other neurodegenerative diseases. LRRK2-targeting therapies also show promise.

Animal research has a long history of promoting the understanding and treatment of Parkinson's disease. Using rabbits and mice, researchers discovered that depleting dopamine in these models caused symptoms similar to Parkinson's. This led to the first treatment for PD, levodopa, in 1970. Rats and monkeys have since been important in helping scientists understand how Parkinson's disease develops. Research with these models led to the development of deep brain stimulation, a kind of "brain pacemaker" in 2002. Researchers transplanting dopamine-producing monkey stem cells into the brains of green monkeys have been able to cure Parkinson's, though additional research is ongoing. Due to the complexity of Parkinson's, animals will continue to play a vital role in understanding the development of the disease, in creating treatments, and in finding a cure.

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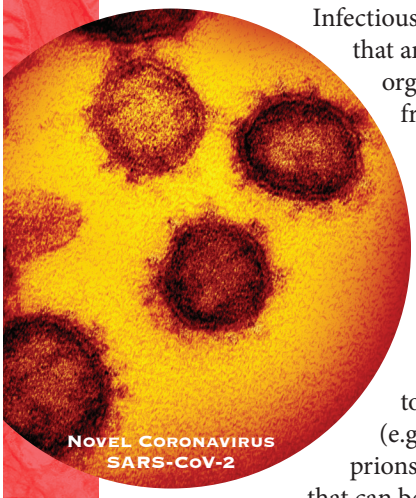
Infectious Disease

- Infectious diseases are a leading cause of death worldwide, particularly in low income countries, and especially in young children.
- Three infectious diseases were ranked in the top ten causes of death worldwide in 2016 by the World Health Organization. They are lower respiratory infections (3.0 million deaths), diarrheal diseases (1.4 million deaths), and tuberculosis (1.3 million deaths).
- Approximately 36.7 million people are living with HIV globally, and one fourth of the world's population, is infected with TB.



Novel Coronavirus SARS-CoV-2

Infectious diseases are disorders that are caused by microscopic organisms that are passed from one person to another, from exposure to an infected animal, or from environmental sources such as soil and water. Infectious diseases are caused primarily by viruses, bacteria, protozoa, or fungi. Though toxins produced by bacteria (e.g., Botulinum toxin) or prions (abnormal proteins that can be transmitted by infectious-type mechanisms) are often classified with infectious agents, even though they are not technically living organisms.

Almost all of these organisms and agents are microscopic in size and frequently referred to as microbes. Examples of diseases caused by viruses are HIV/AIDS, influenza, Ebola, hepatitis, West Nile and the common cold. Diseases caused by bacteria include anthrax, tuberculosis, salmonella, and a wide variety of respiratory, diarrheal and skin diseases. Protozoans cause malaria, Chagas disease, schistosomiasis, and other diseases that are relatively uncommon in the U.S. but are widespread in developing nations including much of Africa, South America, and Southeast Asia. Fungal diseases range from minor skin infections such as athlete's foot to Valley Fever, a debilitating systemic fungal infection common in the Southwestern U.S. Following the U.S. anthrax letter attacks of 2001 there is increased concern about "bioterrorism," (the intentional use of infectious agents to affect civilian populations or members of the military).

National Institute of Allergy and Infectious Diseases-Rocky Mountain Laboratories, NIH

Infectious Disease—continued

Research into infectious diseases decreased sharply in the 1960s and '70s. By this point, a variety of antibiotics had brought most bacterial infections under control, and vaccines were available for the majority of viruses (e.g., small pox, polio, influenza, measles, mumps). This view began to change in the 1980s when a host of new or rarely seen infectious diseases spread through the world including HIV/AIDS, Lassa virus, Ebola, Legionnaire's disease, Hepatitis C, Mad Cow Disease, West Nile, SARS, bird flu, swine flu, MERS CoV, and Zika virus. Nearly every year sees new diseases appearing, underscoring the importance of robust research programs in development of new drugs and vaccines for continually emerging infectious diseases.

Animal models have always played a critical role in the discovery of treatments for infectious disease. While Alexander Fleming is credited with the discovery of penicillin, noting that a mold, Penicillium notatum, killed bacteria growing in a petri dish, it was Howard Florey and colleagues at Oxford University who made the discovery that mice treated with penicillin could survive infection from the usually lethal Streptococcus bacterium. This led to testing in humans and helped change the course of World War II by saving thousands of soldiers who would have otherwise died of infections resulting from battle wounds and pneumonia.

Animal models continue to be widely used today to test both anti-viral and anti-bacterial drugs. The mouse is the most commonly used species for infectious disease testing, but a few human diseases do not affect mice, resulting in a continuing search for new models. For example, ferrets are the primary species besides humans that contract influenza, and they are most commonly used for flu research.

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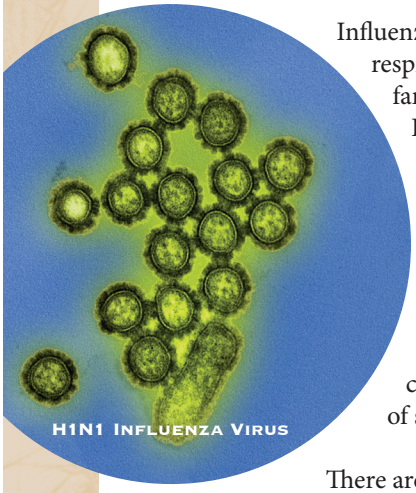
Influenza

- Influenza and penueomona are the 8th leading causes of death annualy in the United States
- In the 2017-2018 Influenza season more than an estimated 80,000 Americans died of flu and its complications
- Ferrets are the best reseach model for influenza research



H1N1 Influenza Virus

Influenza (flu) is a contagious respiratory illness caused by a family of influenza viruses. It can cause mild to severe illness. Serious outcomes of flu infection can result in hospitalization or death. Some people, such as older people, young children, and people with certain health conditions, are at high risk of serious flu complications.

There are two main types of influenza (flu) virus, Types A and B, though within those major types, there are dozens of potential subcategories. Influenza A virus is often characterized by its surface proteins, with designations such as H1N1, H3N2. Influenza B viruses have different subtypes based on lineages with names like B/Yamagata and B/Victoria. The influenza A and B viruses that routinely spread in people (human influenza viruses) are responsible for seasonal flu epidemics each year. New variations are monitored globally for possible pandemic consequences.

People with flu can spread it to others up to about 6 feet away. Most experts think that flu viruses spread mainly by droplets made when people with flu cough, sneeze or talk. These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs. It is also possible to be infected by touching a surface or object that has flu virus on it and then touching the mouth, nose, eyes or other mucous membranes.

The 1918 influenza pandemic was the most severe pandemic in modern history. It was caused by an H1N1 virus with genes of avian origin. This outbreak spread worldwide during 1918–1919. It is estimated that about 500 million people or one-third of the world population at the time became infected with this virus and more than 50 million died from it worldwide. More died from influenza than in combat in World War I.

National Institute of Allergy and Infectious Diseases, National Institutes of Health

Influenza—continued

Vaccinations for influenza have been in use for many decades, but have a serious limitations. Because of the many months required to prepare millions of doses of vaccine for the population, organizations such as the Centers for Disease Control (CDC) need to guess, a year or more in advance, what strains of flu will be circulating the following year. Many years they guess correctly, and some years they pick strains that have limited effectiveness.

Research is underway to find new and improved ways to diagnose, treat, and prevent influenza infection. This includes working toward a universal flu vaccine that could provide long-lasting protection against multiple strains of influenza, such as those that cause seasonal flu as well as emerging forms capable of causing a global pandemic.

Ferrets are the primary reseach model for influenza drug and vaccine research. Ferrets are the only animal, besides humans, that develop the classic signs of influenza: sniffles, cough and elevated body temperature.

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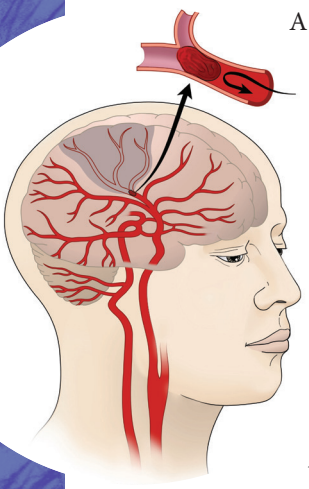
Stroke

- Stroke is fifth leading cause of death in the United States and a leading cause of serious disability.
- Warning Signs and Symptoms of Stoke include weakness of face, arm, or leg, especially on one side of the body, confusion, trouble speaking or understanding speech, trouble seeing, trouble walking, and severe headache.



A stroke is a sudden interruption in the blood supply of the brain. Most strokes are caused by an abrupt blockage of arteries leading to the brain (ischemic stroke). Other strokes are caused by bleeding into brain tissue when a blood vessel bursts (hemorrhagic stroke).

Stroke is a disease that affects the blood vessels that supply blood to the brain. A stroke occurs when a blood vessel that brings oxygen and nutrients to the brain bursts or is clogged by a blood clot, or plaque. Because of this disruption, part of the brain doesn't get the blood and oxygen it needs. Deprived of oxygen, nerve cells in the affected area of the brain can't work and die within minutes. And when nerve cells are damaged, the part of the body they control can't work either. The devastating effects of a severe stroke are often permanent because dead brain cells aren't replaced.

There are three main types of stroke: transient ischemic attack, ischemic stroke and hemorrhagic stroke. Transient ischemic attacks (TIA) are also called mini-strokes. They are caused by temporary disruption of blood flow to the brain.

Ischemic strokes account for more than 80% of all strokes. This type occurs when a blood clot forms and blocks blood flow in an artery bringing blood to some part of the brain. The blood clots usually form in arteries damaged by fatty buildup (atherosclerosis). Other ischemic strokes are cause by emboli (blood clots or other material) that originate in another part of the cardiovascular system.

Hemorrhagic strokes are caused by bleeding in or near the brain, and are classified as being subarachnoid or cerebral hemorrhages. A subarachnoid hemorrhage occurs when a blood

National Institute of Neurological Disorders and Stroke, National Institutes of Health

vessel on the brain's surface ruptures and bleeds into the space between the brain and the skull. A cerebral hemorrhage occurs when a defective artery in the brain bursts, flooding the surrounding tissue with blood. Hemorrhagic strokes have a much higher mortality rate than strokes caused by clots.

Strokes are further defined by the principal arteries affected which influences the types and extent of the clinical signs. Several deficiencies are possible, including impairment of motor function, sensitivity, perception and language skills.

Translation from basic science benchside research in ischemic stroke to bedside treatment of patients suffering ischemic stroke remains a difficult challenge. Despite literally hundreds of compounds and interventions that provide benefit in experimental models of cerebral ischemia, efficacy in humans remains to be demonstrated. The use of animal models in recent years has improved our understanding of the physiopathology of this disease. Rats and mice are the most commonly used stroke models, but the demand for larger models, such as rabbits and even nonhuman primates, is increasing so as to better understand the disease and its treatment. These models have been used to develop new pharmacologic treatments for thrombolysis and reperfusion, which improve clinical outcomes.

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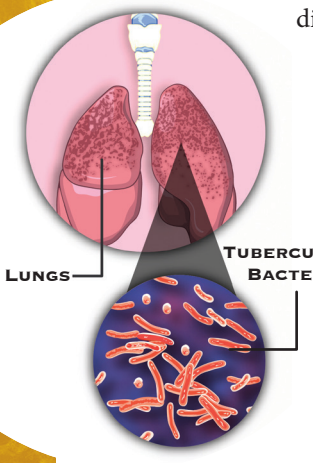
Tuberculosis

- According to the World Health Organization (WHO), nearly 2 billion people, one-third of the world's population, have tuberculosis.
- Tuberculosis is the world's largest infectious killer of women of reproductive age, and the leading cause of death among people with HIV/AIDS.
- More than 23,000 people develop active TB, and almost 5,000 die from the disease every day (one, every three and half minutes) worldwide.
- TB is one of the top four infectious killing diseases in the world.



Tuberculosis (TB) is an infectious disease caused by the bacterium Mycobacterium tuberculosis (MTB), a slow-growing aerobic bacterium that divides every 16 to 20 hours. It is most common in the lungs (pulmonary TB), but can also affect the central nervous system (meningitis), lymphatic system, circulatory system (miliary tuberculosis), genitourinary system, bones, and joints.

Robert Koch first identified and described this bacterium on March 24, 1882, and received the Nobel Prize in physiology or medicine in 1905 for this discovery.

TB is spread by aerosol droplets expelled by people with active TB disease of the lungs when they cough, sneeze, speak, or spit. Transmission can only occur from people with active TB disease (not a latent TB infection). A person with untreated, active tuberculosis can infect an estimated 20 other people per year. Only 10% of latent TB infections progress to active TB.

Those at greatest risk of infection include immuno-compromised patients (e.g., HIV/AIDS, patients on cancer chemotherapy), residents and employees of high-risk congregate settings (e.g., nursing homes), health care workers who serve high-risk clients, medically underserved, low-income populations, high-risk racial or ethnic minority populations, and children exposed to adults in high-risk categories.

Tuberculosis has been present in humans since antiquity. The origins of the disease are in the first domestication of cattle (which also gave

humanity viral poxes). Skeletal remains show prehistoric humans (4000 BCE) had TB, and tubercular decay has been found in the spines of Egyptian mummies from 3000–2400 BCE.

Researchers in the 1940s using animal models of TB, such as rats, mice, and rabbits, developed the first critical step in treating TB with the creation of penicillin, and broad-spectrum antibiotics which revolutionized treatment of bacterial infections, in humans and in animals. In 1946, through research with chickens, and guinea pigs researchers began therapeutic use of streptomycin—the first antibiotic effective in treating tuberculosis, pneumonia, spinal meningitis and typhoid fever.

Further research and the development of additional antibiotics and newer forms of TB vaccines gave great hope to scientists and physicians for the eventual elimination of TB. The rise of multidrug-resistant strains of TB (MDR-TB) and Extreme Drug-Resistance in Tuberculosis (XDR-TB) now emerging have significantly hampered this effort. Researchers continue to search for newer forms of antibiotics, and effective vaccines, including a promising recombinant Tuberculosis vaccine to treat TB and to prevent initial infection. New imaging agents are also being developed to better view TB in the lungs at earlier stages where treatments are more effective.

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Zoonotic Diseases

- There are more than 200 zoonotic diseases
- Worldwide, approximately 55,000 people die each year from rabies
- According to the Centers for Disease Control and Prevention (CDC), 3 out of every 4 new diseases in people originated in animals

Zoonotic diseases are those infections capable of being transmitted from animals to humans. Zoonotic diseases are prevalent throughout the world. Avian flu, COVID-19, West Nile Virus, rabies, toxoplasmosis, Ebola, anthrax, E. coli, salmonella, bubonic plaque, ringworm, and lyme disease, and the coronavirus are just a few of the more widely publicized zoonotic diseases. Zoonotic diseases represent a significant public health threat to humans and to animals.

Zoonotic infections can be viral, bacterial, fungal, or parasitic. In many examples of zoonotic diseases, the infection was once limited to animals and only after mutations was capable of also infecting humans. With zoonotic diseases, humans become infected through direct contact with an infected animal. In other cases, a disease carrier, such as an insect or rodent, is necessary to spread the disease from an infected animal to human. In some cases where the disease has mutated significantly, infection is possible from one infected person to another as well. Many diseases commonly associated with humans originally jumped from other animals to humans. There is good evidence that measles, smallpox, and influenza, were zoonotic, and HIV, the common cold, and tuberculosis also started in other animals before they "spilledover" into humans.

People with weakened or immature immune systems are most at risk of contracting zoonotic diseases. This includes infants and small children, pregnant women, the elderly, cancer therapy patients, and persons with HIV/AIDS. Also at risk are individuals who are in direct contact with animals, such as veterinarians, zookeepers, wildlife specialists, and other animal health care workers.

Zoonotic Diseases—continued

Some zoonotic diseases are density dependent – meaning outbreaks can occur whenever animals are gathered in large numbers – and can contribute to infecting humans with pathogens from zoonotic diseases. A pathogen is a biological agent that causes disease or illness to its host. Wildlife trade and consumption of wildlife are other conduits through which zoonotic diseases can be transmitted. Since zoonotic diseases can also be transmitted from one animal to another, wildlife trade can also occasionally cause the infections of domestic animals.

Diseases such as rabies and Ebola are examples of infections that can be transmitted from animal directly to humans. Some zoonotic diseases can be transmitted indirectly to humans. In these cases, a disease carrier transmits the infection from infected animal to humans. West Nile virus is an example. West Nile is an arthropod-borne virus, which is transmitted by blood-feeding insects such as mosquitoes. Direct transmissions of the virus from animal to people, animal to animal, people to animal, or people to people are not possible. West Nile causes encephalitis (inflammation of the brain) and most infections have been associated with birds, horses, and humans. Bubonic Plague is another example of an arthropod-borne infection. Fleas transmit the diseases from an infected animal, such as rats in the middles ages and prairie dogs in the southwest currently, to humans or other mammals.

Through studying the transmission and progression of such diseases in animals, researchers are better able to understand the mechanisms of the infection, the progression of the disease, the infectious qualities and means. Since these diseases are specific to animals and humans, continued medical research with animal models is imperative. Any vaccines or treatments for zoonotic diseases will need to be developed that treat humans and the animal hosts.

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Biomedical Research in Action

Biomedical research is the broad area of science that involves the investigation of the biological process and the causes of disease through careful experimentation, observation, laboratory work, analysis, and testing. Scientists expand this knowledge base to discover ways to prevent ill-health, and to develop beneficial products, medications, and procedures to treat and cure diseases and conditions that cause illness and death in ourselves, our families and friends, pets, farm animals, and wildlife. Biomedical research requires the input and participation of many individuals with many different backgrounds and skills from both the life and physical sciences. Such a research team might include medical doctors, veterinarians, computer scientists, engineers, technicians, laboratory assistants, researchers, and a variety of scientists from the many different fields of the life sciences.

The Results of Biomedical Research

People all over the world live longer, healthier lives due to the significant advances of biomedical research. The list is almost endless: vaccines against polio, diphtheria, mumps, measles, rubella, smallpox, hepatitis, meningitis, and chicken pox; open heart surgery, pacemakers, and artificial heart valves; kidney, liver, heart, lung, and pancreas transplants; antibiotics and anti-depressants; medications for diabetes, ulcers, mental illness, arthritis, asthma, epilepsy, and high blood pressure; treatment (and cures for many forms) of cancer; development of artificial blood vessels and skin for grafting; external filtration of blood for patients awaiting liver transplantation; advances in vaccine and anti-viral therapy for HIV/AIDS; and the current search for treatments and cures for the new wave of infectious diseases to name only a few.

Many of the advances in veterinary medicine are the direct result of pre-clinical research as well: vaccines for rabies, heartworm, parvovirus, and feline leukemia; joint replacement, pacemakers, and organ transplantation for cats, dogs, and horses; treatment for diabetes; and extensive veterinary antibiotics are a few examples. In addition, research in reproductive physiology and artificial insemination has saved certain wild species, like the African wild cat, the California condor, and the panda bear from possible extinction.

For more information on biomedical research, the research process, and free educational resources please visit our website www.ca-biomed.org/csbr

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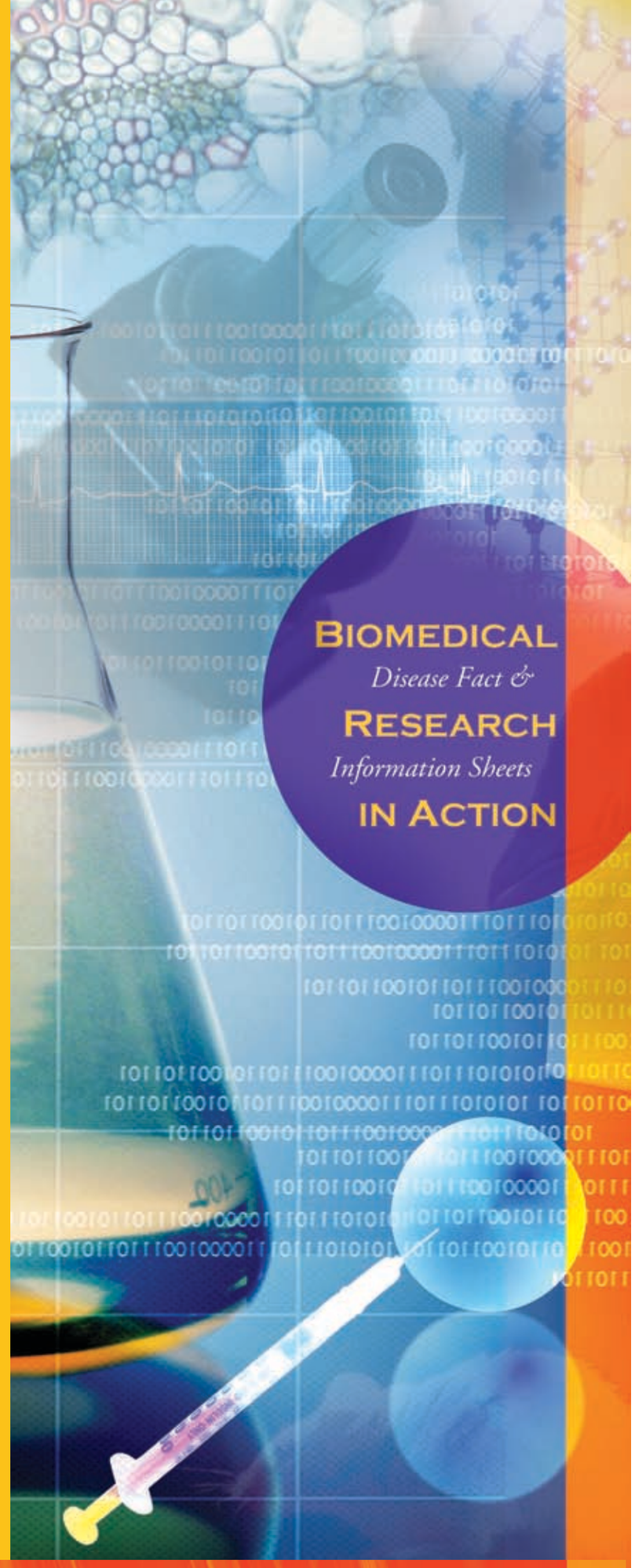

Biomedical Disease Fact & Research Information Sheets in Action

The Scientific Method is observation, hypothesis, experimentation, and conclusion.

Basic research is conducted to increase fundamental scientific knowledge and to expand our understanding about how processes in living organisms develop and function. It provides the building blocks upon which other types of biomedical research are based.

Applied research is directed towards specific goals and discoveries, such as the development of a new medication, medical device, or a surgical procedure. It involves using existing knowledge (gained from basic research) and methodically expanding this knowledge to address the specific medical problem.

In vitro research (from Latin meaning "in the glass") refers to experiments with bacteria, cell, tissue, and organ cultures done in laboratories.

Ex vivo research (from Latin meaning "out of the living") refers to experimentation done in or on living cells or tissues taken from an organism and cultured in a laboratory apparatus, outside the organism. The living cultured cells serve as models of the whole organism, reducing the need for in vivo research.

In vivo research (from Latin meaning "in the living") takes place inside an organism – experimentation done in or on the living tissue of the whole body. Pre-clinical trials and clinical trials are examples of this type of research.

Pre-clinical trials involve non-human animal models, and assist researchers in furthering their knowledge and in discovering more effective methods for diagnosing, treating, and curing diseases that affect both humans and animals. Because animals are biologically similar to humans and are susceptible to many of the same diseases and health problems, researchers use animals as models during more advanced stages of biomedical research. Approximately 96 percent of all research animals in the United States are rats, mice, and other rodents bred specifically for laboratory research. Pre-clinical trials are an essential part of the biomedical research process because nothing can substitute for the complex functions of the whole, living organism.

Researchers avoid the use of animals in research whenever it is possible, and continue to search for alternative methods. They subscribe to **The 3 Rs** – (Reduction, Refinement, and Replacement). Reduction refers to methods that result in fewer animals being used to acquire the needed information. This, in some studies, eliminates the use of animals. Refinement concerns the manner in which the animals are used. This includes new and more effective anesthetics and analgesics, species-appropriate housing, and enrichment activities. Replacement means using methods that do not involve whole animals. Computer models and in vitro and ex vivo are examples.

Clinical trials take place in a hospital or a clinical setting, and involve informed human volunteers to gauge the safety and effectiveness of drugs, procedures, or medical devices. Human studies can only begin after exhaustive studies and regulatory evaluation, including pre-clinical trials, have been conducted. There are three major phases of clinical trials, all done in careful coordination and with the approval of the U.S. Food and Drug Administration (FDA), before approval is gained or rejected.