

# Parkinson's Disease



Parkinson's disease (PD) is a neurodegenerative disorder, that is, a disease in which brain cells progressively die. Symptoms include tremor, rigidity, extreme slowness of movement, and impaired balance. Swallowing and speaking difficulties are also common, as are several non-motor symptoms that seriously affect quality of life.

## Yesterday

- Basic research on chemical signals in the brain, called neurotransmitters, led to recognition that the symptoms of PD reflect loss of nerve cells that normally release the neurotransmitter dopamine.
- Recognition of the loss of dopamine cells in PD led to development of the drug levodopa, which nerve cells turn into dopamine. Levodopa dramatically reversed symptoms of PD for several years in many people.
- Levodopa, however, did not slow the underlying neurodegeneration and became less effective as PD progressed. Levodopa also induced side effects including uncontrolled movements, called dyskinesias, and "on-off" fluctuations in symptom control.
- Brain surgery that permanently destroyed regions of tissue involved in PD provided some benefit for people with the disease. This was the only validated non-drug therapy available at that time.
- Neurosurgeons also transplanted fetal tissue, adrenal tissue, and other cells that might produce dopamine into the brains of people with PD. The safety and effectiveness of these procedures were controversial.
- With the exception of a few PD-like disorders associated with viral infections, certain toxins, and a "punch drunk" syndrome exhibited by aging boxers, the origins of PD were mysterious.

## Today

- Although estimates vary, about 50,000 people are diagnosed with PD in the U.S. each year and about half a million people have the disease. Because the rate of PD increases in older adults, the burden will increase unless prevention and treatment improve.
- Levodopa is still the mainstay of drug therapy. Several additional drugs are now available that complement levodopa therapy, but none significantly slows the underlying neurodegeneration.
- Discoveries about how the brain controls movement and improved technology led to Deep Brain Stimulation (DBS). DBS improves symptoms of PD by electrically stimulating brain cells in movement control areas of the brain through chronically implanted electrodes. A joint Veterans Administration –NIH clinical trial confirmed the benefits of DBS for advanced PD, and efforts to improve DBS are ongoing.
- Two NIH-supported clinical trials of fetal tissue transplantation demonstrated that this approach to treating PD is problematic, causing serious dyskinesias. However, results also provided encouragement for better controlled methods of cell transplant therapy.
- Research has identified several genes that can cause rare inherited forms of PD and other genes that influence age of onset and susceptibility to common PD. Ever more powerful gene discovery methods, including Genome Wide Association Studies and Deep Sequencing, are now revealing more genetic contributions to PD.
- Gene findings are yielding clues about what kills brain cells in inherited and non-inherited PD and suggesting new strategies, now at various stages of testing, to slow the course of disease.
- Several studies suggest environmental influences on PD. Exposure to certain pesticides may increase risk, and higher intake of vitamin D, caffeine, and tobacco may be associated with lower incidence. For most people with PD, genes and environment may both contribute—genes load the gun, and environmental exposure pulls the trigger.
- Despite remarkable improvements in brain imaging, PD is usually not diagnosed until overt symptoms are present. At this stage, most of the dopamine nerve

cells in the brain areas affected by the disease are already lost, challenging therapies that aim to slow disease progression.

- Researchers now know that PD also affects non-dopamine cells in the brain, contributing to the non-movement symptoms. These symptoms may begin even before the movement problems or emerge in advanced PD. Non-motor symptoms are receiving increasing attention because they impair quality of life and are not adequately treated by existing therapies.

## Tomorrow

- Better understanding of genetic and environmental contributions to PD and their interaction will enable physicians and patients to assess personal risk for PD and perhaps take steps to reduce risk.
- Intensive efforts are underway to develop biomarkers, which are measurable indicators of the disease process. Biomarkers will detect PD early, before irreversible damage to the brain, and will speed clinical trials of therapies, reducing the time to test whether new treatments are slowing degeneration from years to months.
- In the future, drugs will not just mask PD symptoms, but will slow or stop the underlying degeneration. Clinical trials supported by NIH and industry are now testing such drugs, including antioxidants, natural nerve cell survival factors, and neurotransmitter-related agents. Several more drugs designed to interrupt specific molecular steps in the disease process are moving toward clinical testing.
- The NET-PD program (<http://parkinsontrial.ninds.nih.gov/>) has already facilitated the review of more than 100 drugs, and the NIH will be supporting a large Phase III clinical trial of creatine, the most promising drug examined to date.
- Other NIH-supported trials involve the testing of the antioxidant coenzyme Q10, the fat molecule GM1 ganglioside, and the use of DBS in different brain regions – in order to identify the optimal brain target for stimulation and to provide surgeons with a body of reliable clinical data on which to base their recommendations to patients.

- With better knowledge of the role of pesticides and other environmental agents in causing PD, effective prevention will be possible by eliminating or reducing use of specific environmental agents or by developing safe handling equipment and methods that will eliminate exposures that cause PD.
- Gene therapy for PD has shown promise in animals and is now moving into first stages of clinical trials in people. Strategies closest to the clinic, including boosting the capacity of nerve cells to produce neurotransmitters or providing molecules that promote nerve cell survival, may benefit people with inherited or non-inherited PD.
- Stem cells may ultimately replace brain cells lost to PD or act as delivery vehicles for nerve cell survival promoting factors, but first uses will be to study the disease process, identify drug targets, and screen potential drugs. Among ongoing efforts, scientists are exploring induced pluripotent stem cells (iPSCs), which are derived from PD patients' own skin cells.
- Researchers are continuing to advance brain stimulation therapies through improved technology and studies of how DBS affects the brain. —For example, optogenetics inserts light-sensitive proteins into nerve cells, which allows precise stimulation of brain cells with light pulses. Scientists are now using optogenetics in animals to understand PD and DBS. In the future, optogenetics, nanotechnology, and other new technologies may treat PD in people.
- Clinicians will also have better treatment options for non-motor features of PD. Similarly, clinicians, researchers, and people with PD will better understand the broad effects of PD and the overlaps between mechanisms of PD and other diseases, which are becoming increasingly apparent as research determines the molecular steps in neurodegenerative diseases.

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