Our brains are similar to remarkably improved computers. They consist of billions of little, interconnected parts that work in harmony through programmed ways to create thoughts, emotions, and acts. And just like computers, from time to time we can learn about the ways things work when they don't.

In 1790, a French doctor Philippe Pinel established the science of psychiatry, the field of brain diseases, damages, and sicknesses that have provided astonishing insights into the internal functioning of our minds and brains. Because of this is that those kinds of disorders make us recognize how solid biological shifts in our brains influence our ideas, emotions, and behavior.

Lately, technological developments have let us examine disordered minds more deeply than ever before. That review shows some of the most significant insights that modern neuroscience has gathered from the before-mentioned study. We will see the things that we can get from autism about the brain's social structure, from schizophrenia about creativity, from Alzheimer's about memory, and so on by combining biology, psychology, and neuroscience.

Chapter 1 - Abnormally working brains may help us to understand the way brains normally work.

Everyone gets extremely sad sometimes. Wild ideas, strange urges, and moments of anxiety, euphoria, or forgetfulness might be experienced from time to time. But what if we are always like that?

The time usual mental activities become overwhelming and start to affect our usual days, that might be an indicator of mental disease. Mental diseases like depression, schizophrenia, or dementia are usually identified by caricatures of usual ideas, emotions, and actions. For instance, if you are clinically depressed, you don't feel sad sometimes– you feel extremely sad for long times like months.

In 1790, French physician Philippe Pinel found psychiatry which is the medical field for mental diseases. Pinel was the first scientist that suggesting mental diseases have a physical base.

Today, we know that all psychological problems are also neurological problems. Genetic errors, environmental circumstances, or damage may malfunction the brain's normal nature and function. Since physical differences and their impact on a person's ideas, emotions, and behavior are related, mental diseases show lots of about the way our brains work.

We should understand some basics without diving into that area of study. The brain is built up of millions of specific nerve cells named neurons that form complex systems to deliver information through our brain, body, and sensations, which cause our mental processes. Neurons interact with each other thanks to a system of electrical signals, and chemical molecules called neurotransmitters. In lots of mental diseases, some networks of neurons turn dysfunctional, hyperactive, or incapable to interact.

Modern neuroscience examines the reasons and the ways that happen, benefiting from recent scientific technologies. Nowadays scientists can change, delete, or insert specific genes in rats to understand how those genes influence the brain, for instance. As a consequence of that animal models, we learned that there are basic genetic diseases of the brain such as Huntington's that are originated from one mutated gene and complicated genetic problems such as depression that include numerous genes and environmental circumstances.

Additionally, modern brain displaying methods enable neuroscientists to examine the activity of the brain while functioning. For example, fMRI records changes in the concentration of oxygen in red blood cells to resolve the parts of the brain that are functioning at a random time. Thanks to those technological developments, the area of brain diseases are lighting into the healthy brain.

Chapter 2 - Autism shows the social aspect of our brains in detail.

Have you ever heard that most people are able to read minds? At least our brains say so.

Since human beings are social beings, our brains learn to assign opinions and feelings to others almost automatically. About three years old, many kids start to realize that the people around them have a mind of their own. Just like psychologists said that theory of mind, helps them get and foretell other people's action, and allows them to drive into the social world fast and efficiently. However, for autistic kids, those things are not that simple and not automatic.

Autism is a developmental disease starting at the beginning of childhood, and mainly strikes a person's social and communication abilities. Autism has a broad spectrum, the meaning of it is that there are lots of variations of severity, but many autistic kids have big issues about understanding other people's thoughts and feelings, reacting properly to others, and learning a language early in life.

Additionally, kids who have autism have a great tendency to stay alone instead of playing with other kids. To continue, they are usually more sensitive to change too, preferring things to keep the same that's why most of them enjoy monotonous play with the same toys, again and again. That causes another property: numerous autistic people have savant-like abilities in a very particular area like drawing or arithmetic.

Lots of those signs can be related to the point that in autism, parts of the brain don't develop well, while the others develop early to make up for the lack. In 1990, Leslie Brothers from the Medicine School from UCLA discovered that the brain parts that disordered in autistic kids mainly include emotion, language, and communication, but further, parts included in visual understanding and movement. Brothers suggested that in normal brains, those parts form a sort of social brain that assists us process information about other people in a specific way.

Since they experience a problem with the development of the social brain, autistic kids have some problems developing a theory of mind, communicating with other people, and identifying human looks and movement. Imaging brain shows that for autistic kids, a person's walking is not very different from the arms of a clock moving. However, in usual kids' development, any human or human-like move triggers the social brain automatically.

In that way, autism gave us an incredible chance to study the special social structure of our brains.

Chapter 3 - Mood complications are related to chemical balance problems including the brain's emotional system.

Feelings are an important part of the way we experience life. They help us interact with other people, understand our wishes, and make judgment calls the time reason only won't satisfy. The time that the emotional system in our brains confuses, it may create a huge amount of pain.

In mental diseases such as PTSD or depression, the brain stucks in a circle of very negative feelings, concluding in a lastingly bad mood or dramatic mental pain. Sadly, that type of disorder hit almost one-third of Americans at least one time in their lives – making understanding and helping them became more critical.

All of our moods and feelings develop from some fundamental emotional responses. Those primal feelings are strongly fixed in our brains since they assisted our forefathers to survive. For instance, if you see a bear, it is more reasonable to feel afraid immediately, instead of spending time and energy to critically judge the risk of the position.

Emotional responses such as fear might be instinctive, but they can be acquired from experiences too. For instance, if a rat learns to connect a specific sound with an electric shock, it will learn to scare from the sound itself shortly. After that kind of association has been made in the deep emotional parts of our brains, it is very difficult to unlearn – which is the reason mood and anxiety diseases can be so difficult to handle.

A set of brain structures called the limbic system essentially regulates emotional responses. The limbic system involves the hypothalamus that controls bodily responses like a pounding heart or sweaty palms and the amygdala that is responsible for orchestrating the initial emotional response.

The amygdala and hypothalamus of people who are dealing with depression, PTSD, and other kinds of anxiety disorders, are overactive all the time and many chemicals that are used for communication are imbalanced. Scientists have come to the conclusion that all of the people who have these disorders have chronically high levels of cortisol, which is the body’s stress hormone. And excess cortisol can have effects on sleep, energy, and appetite.

While studying the working principles of antidepressants, scientists also discovered that people who have depression and anxiety have relatively less of the neurotransmitter serotonin in their brain. Serotonin, which is a chemical messenger molecule, is used for the neurons to communicate and has a role in many mental processes such as emotion, cognition, memory, and learning.

Chapter 4 - Schizophrenia influences numerous brain parts related to thinking, memory, and creativity.

Since it has an influence on several brain regions and therefore causes many significant effects on thinking and behavior, schizophrenia is still one of the most stigmatized mental disorders.

People who are suffering from schizophrenia, often have visual and auditory hallucinations and paranoid delusions. They might be convinced that someone is trying to send them special messages or that people are out to get them. But people with schizophrenia can also have less obvious symptoms like withdrawal, lack of motivation, and memory problems.

The fact that schizophrenia causes many significant structural changes in the brain is linked to an excess synaptic pruning in the adolescent years. The connection points between neurons are called synapses and a toddler’s brain has almost twice as many synapses as adults. When puberty hits, some of these connections in the brain are cut in order to make mental processes more efficient and streamlined. However, in the brain of a person with schizophrenia, this pruning process gets out of control. So, some parts of the brain like the prefrontal cortex, which plays a big role in planning and decision-making, and the hippocampus, which helps with memory, might not develop as it was supposed to.

It seems that this excessive pruning has a genetic basis. Studies have shown that a person with schizophrenia most likely has, a particular variant of the gene called C4, which tags the synapses for pruning. The overexpression of this gene causes more connections to be cut than necessary.

Dopamine, which is another neurotransmitter, also has a crucial role in schizophrenia. Dopamine is a complex chemical messenger, just like serotonin. And It has an important role in functions like memory, emotion, movement, thought, and behavior. It seems that people with schizophrenia have an excess of dopamine in their brains.

One feature that is very surprising is that many incredible and original artwork has been produced by people with schizophrenia. For example, in the early nineteenth century, a book that involved an Italian physician Cesare Lombroso’s first collection of schizophrenic art has become the founding bible of the Dada and Surrealist movement

Mental disorders have been thought to be linked to creativity for a long while and later studies have exposed that creative people are more likely to have a mental disorder in their lifetime. For instance, Jack Kerouac was known to have schizophrenia and Vincent Van Gogh was likely bipolar. Science is still lacking the exact answer to why this link exists, however, there is one theory that states that by having constraints to thinking, these people have broader access to their unconscious minds, therefore being more creative.

Chapter 5 - In Alzheimer's and dementia, defective proteins damage the part of the brain, explicit memory system.

Henry Molaison who was only known as H.M. by his doctors was one of the most important patients of the history of neuroscience. Though he wasn't very lucky, as most of them were not as well. As a child, he had a bike accident that caused a head injury, resulting in him suffering from epilepsy in this adulthood. His doctors made the decision to take the parts of his brain that were injured from the accident, in order to stop the seizures.

This operation had cured H.M.'s epilepsy, but with a high cost. Although he could remember people and events from his past, he was unable to form new memories. He forgot every piece of new information that he learned after the operation instantly. The surprising thing is that he was able to acquire new motor skills like drawing, though he didn't remember practicing.

It is revealed after the case of H.M., that the brain has two different memory systems: one that helps us remember events and people called explicit memory system, and the other that is responsible for remembering the learned motor skills, like playing the piano or riding a bike. The part of the brain, the hippocampus which plays a crucial role in explicit memory, had been removed from H.M.'s brain.

Alzheimer's disease and dementia, which are two of the most common disorders that affect memory, also affect the hippocampus, can progressively destroy memory. Yet in these disorders it is not the adventurous doctors that do the damage, it is the faulty proteins in the brain.

It gets a little problematic from now on, but if you bear with us you can learn what is done wrong by these proteins. In a healthy case, these proteins fold into a distinctive, three-dimensional shape and this unique shape is crucial to its function since the proteins fit into specific receptors in the brain like a lock and key. However, in Alzheimer's and dementia instead of folding accurately these proteins clump together. And that's what scientists call abnormally folded protein prions.

Misfolded proteins usually first appear in the prefrontal cortex, and then they start to occur in the hippocampus which is where explicit memory is. Primarily they cause a loss of connection between the neurons, and in the later stages, kill the neurons altogether.

Although we've learned a lot about how seemingly insignificant changes in the brain can have far-reaching consequences from memory-related disorders, the discovery of prions has exposed new possibilities for the treatment options of these diseases.

Chapter 6 - Parkinson's syndrome shows the effect of brain chemicals in movement.

It's not just Alzheimer's and dementia that are caused by misfolding proteins. There are many ways a faulty protein can affect a human's thoughts and behaviors because there are many different proteins in the human body. For example, in Parkinson's and Huntington's disease, a person's ability to move is slowly destroyed by the misfolding proteins.

It is very easy to forget the fact that our bodies are controlled by our brain when we're healthy since movement feels so natural. There is a specialized network of neurons that emerge in the brain, and goes down the spine, and connects to all 650 muscles in the body, in the motor system. While some of these neurons send signals from the brain to the muscles with the intention to begin a movement, other neurons send signals from the muscles to the brain in order to give feedback about this movement.

This signal loop of a normal functioning body is disturbed when the person has Parkinson's disease. Resulting in the typical shaking and a limited range of motion that usually starts in a person's sixties. It was in 1817 that a British doctor with the same name described Parkinson's. However, it wasn't treated as a brain disorder until much later mainly because it has many physical symptoms.

It was discovered by scientists in the early years of the 1900s that a region of the midbrain named substantia nigra because of its distinctive black pigmentation was far lighter in the brains of those with Parkinson's than healthy brains. The neurons that supply the neurotransmitter dopamine are in the substantia nigra and just as how schizophrenia is caused by an excess of dopamine, Parkinson's has resulted from the lack of dopamine.

In Parkinson's, the neurons that are responsible for producing dopamine in the substantia nigra are cut off by misfolding alpha-synuclein proteins. What scientists have found out when studying fruit flies is that a spontaneous mutation on the SNCA gene makes the protein misfolding, but the causes are still unknown.

In the beginning, the neurons in the substantia nigra become overactive to make up for the loss in function, but ultimately they can't produce dopamine because they are killed by the protein clumps. Dopamine has many functions one of which is muscle control. In Parkinson's, there is a characteristic tremor due to the lack of dopamine. And that region has a lighter color in Parkinson's patients because of the neurons slowly dying.

Chapter 7 - Addiction occupies the brain’s reward system – usually lastingly.

Until recently, even psychologists thought that addiction was a matter of willpower only. Why don’t they just stop it when a pleasurable behavior destroys their health and relationships? But now that we have neuroscience, we know it is not that simple of a deal.

Addiction to drugs, alcohol, gambling, or eating can fundamentally change our brain like any other mental disorder. It robs us of our will by mainly acting on the systems involved in pleasure, emotions, and behavior. Though this came at a massive price like 740 billion dollars a year for the US economy.

The brain’s dopamine reward system adjusts the pleasure we get from food, sex, or drugs. This system has the dopamine-producing neurons in the substantia nigra, which extend deep into the hippocampus, amygdala, and striatum. Don’t forget that the hippocampus deals with memory, while the amygdala regulates basic emotions. And if you add to this the striatum, you have a brain region that is crucial for forming habits.

Overall, you learn to look out for pleasure-inducing experiences, like those experiences that make your brain release dopamine, from the brain’s reward system For example if you eat a tasty banana, you will have a moderate amount of dopamine released. And since your brain saves this experience, later when you see a banana you’ll want to eat it more. If your brain releases more dopamine during an experience, your reward system will be more determined to experience that.

As you might have guessed most habit-forming drugs and experiences induce a bigger dopamine response than eating a banana. For instance, cocaine results in a release of dopamine, but also directly interferes with the system that is responsible for getting rid of the dopamine from the synapses, causing it to stay around in the brain longer.

It’s not just the association of the drug with pleasurable dopamine-release, that, the reward system learns but, it’s also the places, people, and music that are among it. Meaning that for addicts, just seeing a person associated with the drug somewhere can send their brain into the compulsive pleasure-seeking mode. To the extent that scientists know today, the pleasure associations are in the brain permanently. Resulting in a high rate of relapse rate amongst recovered addicts, and addiction to be treated as a chronic disease.

Chapter 8 - The improvement of our bodies and brains leads to several variations in sex and gender identity.

Male and female animals show vast differences in behavior in many species. Humans are not an exception to this, but we have a much wider range and variety of gendered behavior than other species.

Nevertheless, small structural and molecular differences were found in the brains of men and women by neuroscientists. For example, different activity patterns exist in areas related to sexual and reproductive behaviors, but there are also gender-specific activity patterns in regions dealing with emotion, memory, and stress. Although we don't know how these patterns show themselves in thought and behavior, it seems that sex and gender also express themselves in the brain.

To start off: the sex that we're assigned at birth because of our external genitalia, like female, male, or intersex, and gender is not the same thing. It is possible that a person has female genitalia but identifies as a man. And there are three distinct types of sex, which complicates things even further.

Our external genitalia, usually a penis or a vulva, determines the anatomical sex, and gonadal sex is determined by our internal genitalia like our ovaries and testes that produce different sex hormones. Lastly, our chromosomal sex is determined by the sex chromosomes we get from our parents. Two XX-chromosomes usually result in female anatomy, while an X and a smaller Y-chromosome usually result in male anatomy.

The anatomical development in the uterus starts in week six or week seven. The formation of the testis gets initiated by a gene called SRY if the fetus has a Y chromosome. Later, the testis releases as much testosterone as males release during puberty, and that makes a male fetus develop. However, if there isn't any Y chromosome, the fetus will develop female anatomy.

The body releases more of that sex hormone, either testosterone or estrogen, a little while after birth, which seems to affect the development of gender-specific brain patterns for behavior, like aggression and mating.

For a lot of people, both their gender identity and their anatomical, gonadal, and chromosomal correspond to each other. However, there are many opportunities for disruptions and variations because these characteristics all develop at different times.

For example, because of certain gene mutations, anatomical sex can be dissociated from gonadal and chromosomal sex. Anatomical "women" who have the gene for congenital adrenal hyperplasia (CAH) are exposed to an excess amount of testosterone in the womb which usually happens to anatomical boys. Consequently, a small but statistically significant amount of these women identify as bisexual and homosexual, and another significant portion identify themselves as trans men.

Chapter 9 - Neuroscience is starting to solve the puzzle of consciousness.

Out of all the complex mental states in the brain, consciousness is one of the most confusing features of them all.

Basically, we use the term conscious as being aware of our mental processes while they're happening. Experiences like, seeing a friendly face, smelling a rose, or being afraid when we're awake are some of those that we can think and talk about later because they have a subjective quality.

There is a link between our general level of consciousness and the brain's general level of awareness. Our brains are more active when we're awake than if we were asleep for instance. And it is the least active when we're in a coma. It seems that a part in the upper brain stem modulates this level of consciousness. But when it is stimulated electrically, we wake up from sleep.

It is also neuroscientists' business to try and find out at what point exact mental experiences become conscious, and which particular regions of the brain are working in these experiences. Famous psychoanalyst Sigmund Freud's suggestions from the nineteenth-century seem to be supported with what scientists have discovered so far with brain imaging. Firstly the mind can clearly be divided into conscious and unconscious processes. Secondly, the unconscious processes have a more significant effect on our thoughts, motivations, and behavior than we would like to admit.

Cognitive psychologist Bernard Baars introduced the theory of the global workspace in order to explain why some mental experiences become conscious but others don't. According to this theory, the deeper layers of the brain are processing sensory information from our surroundings unconsciously, all the time. But to make it available in the conscious global workspace, we direct our attention to a piece of information and our brain picks up the initial sensory signal and broadcast it to higher brain regions.

When an image is shown to us subliminally so quickly that we cannot consciously identify or remember what we've seen, the visual cortex in the back of the brain gets very active for 200 to 300 milliseconds. And after that time is over, the signal dies down. But if the image is shown long enough the visual signal doesn't die down, and instead is propagated and amplified throughout the entire brain. It is only then possible for the image to become conscious in the global workspace.

There's still a lot of things to be explored for the way our brains produce consciousness, by neuroscience. But with the new technologies merged with psychology, psychiatry, and biology, we might be able to solve the great mystery of how the brain works.

The Disordered Mind: What Unusual Brains Tell Us About Ourselves by Eric R. Kandel Book Review

Since there's a link between all mental disorders and the changes in our brains, we can learn a lot about how our brains affect our thoughts, feelings, and behavior from those. Most mental disorders are caused by both genetic and environmental reasons. While some disorders like autism and schizophrenia make anatomical changes in the brain, others like depression and Parkinson's originally affect the chemicals that our brain uses to communicate.

Exercise to keep your mind sharp.

Is the fact that our bones release a hormone called osteocalcin, news to you? One of this hormone's functions is to urge the production of certain neurotransmitters in the brain, that boosts our memory. Therefore scientists believe that age-related memory loss could be caused by the decrease in bone density in old age. So if you want to keep your mind sharp, working out your body might help you, since exercise promotes bone density.

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