Mysteries of the Brain: Building a Brain

Dr. Carlos Aizenman, a neuroscientist at Brown University, is studying the brains of tadpoles between two days and three weeks old to understand how neural circuits develop and absorb information from the surrounding environment. "Mysteries of the Brain" is produced by NBC Learn in partnership with the National Science Foundation.

Keywords

Citation
MLA
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TOM COSTELLO, reporting:

A bird snatching a fish from the ocean, a frog jumping from a lily pad, an artist painting a portrait-- all of these actions depend on the animal's nervous system, and at the center of it is the brain, the vital organ that controls all of an animal's thoughts, emotions and behaviors. Although different species have brains of varying shapes and sizes, the formation of all brains and their neural circuits follow a similar developmental principles.

CARLOS AIZENMAN (Brown University): It's vital to study brain development in order to just understand normal development but also abnormal development.

COSTELLO: Carlos Aizenman, a neuroscientist at Brown University is funded by the National Science Foundation. He’s trying to understand the basic biology of how neural circuits develop. Neural circuits are made up of networks of cells called neurons that generate electrical and chemical signals in order to communicate with one another. Each circuit is responsible for a different action or behavior. These circuits are sculpted by how the animals interact with their surrounding environments starting at the earliest stages of life.

AIZENMAN: Say you're interested in studying how vision is processed, there will be certain groups of neurons that form a circuit that will be activated when you experience a certain type of visual stimulus.

COSTELLO: To unlock answers about the development of neural circuits, Aizenman and the students in his lab are studying the simple structure and wiring of tadpole brains from a type of frog called xenopus laevis, or African clawed frog. Their brains are about four to five millimeters long and about just one millimeter wide. Aizenman and his team are focusing on a region of the tadpole's midbrain that is just .3 millimeters wide, called the optic tectum, in order to understand how experience from the tadpole's environment plays a role in development.

AIZENMAN: In frogs, that is their main sensory processing area. And if you look at a frog brain or a
tadpole brain, you'll see that one of the most prominent parts of the brain are the optic tecta. And therefore, it must be very important to the frog's survival.

COSTELLO: Tadpoles are bred in Aizenman's lab every week and kept in an incubator at various stages of development, from two days old to two to three weeks old when they are actively exploring their environment.

TORREY TRUSZKOWSKI (Brown University): This is a stage-49 tadpole. On either side these dark spots are the eyeballs. Right here, this is one nostril and here's the other one. And then underneath this dark spot, these are pigmented melanocytes, so skin cells, and underneath that is the actual brain itself.

COSTELLO: After extracting a tadpole's brain, students use a technique called electrophysiology to probe individual neurons with electrodes in order to amplify and measure the electrical activity of the neuron.

TRUSZKOWSKI: What I’m recording here is the activity of the cell in response to the stimulating electrode that I have placed on the visual input pathway. There's tons of activity going on here.

COSTELLO: Students also study the tadpole's behavior in a collision avoidance experiment. This helps them understand the state of the tadpole's visual networks, which are sculpted by its experience early in life.

During the experiment, a tadpole is put into a petri dish on top of a monitor. A dot representing the tadpole's predator is then projected onto the monitor screen and moved towards the tadpole to elicit an escape response.

The students record the tadpole's behavior-- swim speed before the dot approaches and after the tadpole notices the dot, as well as the distance between the tadpole and the dot at the moment the tadpole notices the dot.

CAROLINA RAMIREZ VIZCARRONDO (Brown University): By studying these behaviors, we can characterize them, and when we expose tadpoles to certain pharmacological agents, if they have different speeds or different execution of this behavior, we can tell that there is dysfunction at that particular circuit.

COSTELLO: By studying the tadpole's simple brain structure and the way it processes information during the early stages of life, Aizenman and his team hope to get one step closer to understanding neural circuit development.

AIZENMAN: There's a lot going on in the developing brain. That's why it's an interesting and remarkable process.

COSTELLO: A process that keeps neuroscientists like Aizenman pushing for answers in brain development.