We have succeeded in taking this picture, and if you look at it you see a dot. That's here. That's home. That's us. On it, everyone you've ever heard of, everyone who ever lived, lived out their lives on a moot of dust suspended in a sunbeam.

Carl Sagan, Pale Blue Dot

Arizona State University
SES 194

Energy in Everyday Life

Photovoltaic I

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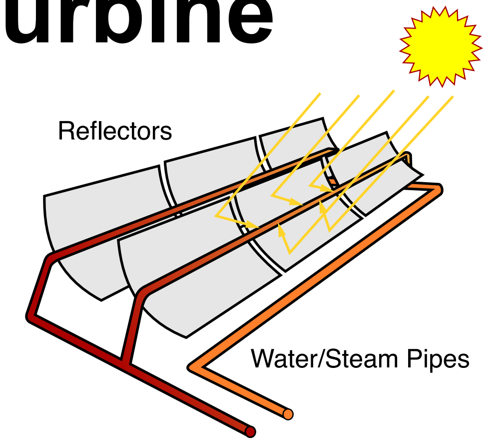
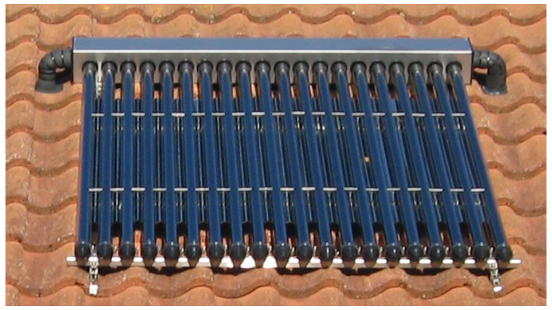
Solar energy is light (photon energy) from the sun harnessed using a range of evolving technologies such as:

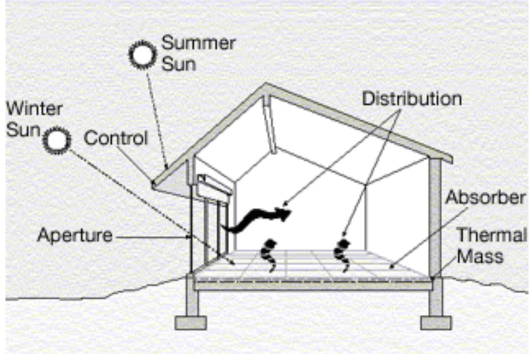
solar photovoltaics - direct conversion to electricity

solar thermal electricity - boil water to drive steam turbine



solar heating - hot water generation





solar architecture - block summer sun, allow winter sun

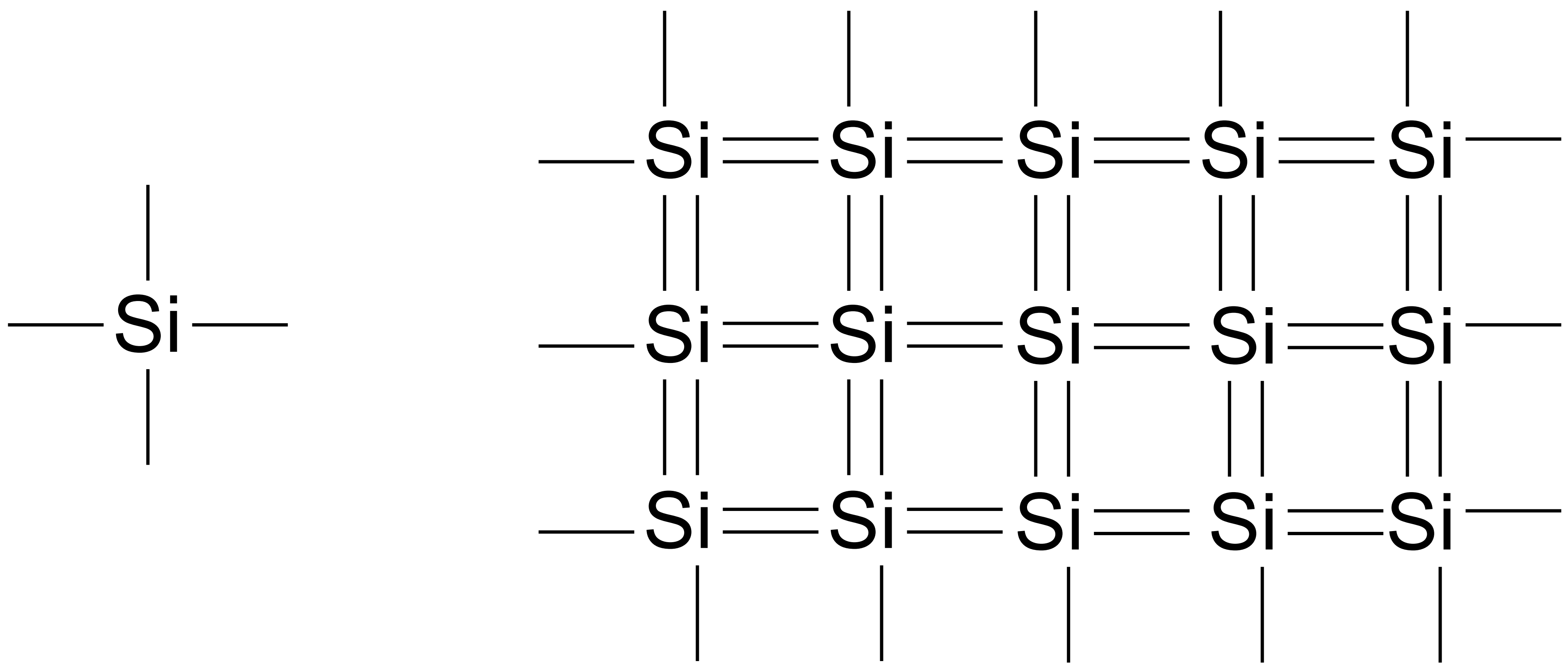
Photovoltaic (PV) cells are made of semiconductors such as silicon, which is currently the commonly used material.

Basically, when light strikes the cell, a portion of the light knocks electrons loose, allowing them to flow as a current.

By placing metal contacts on the top and bottom of the PV cell, we can draw that current off to, say, power a cell phone.

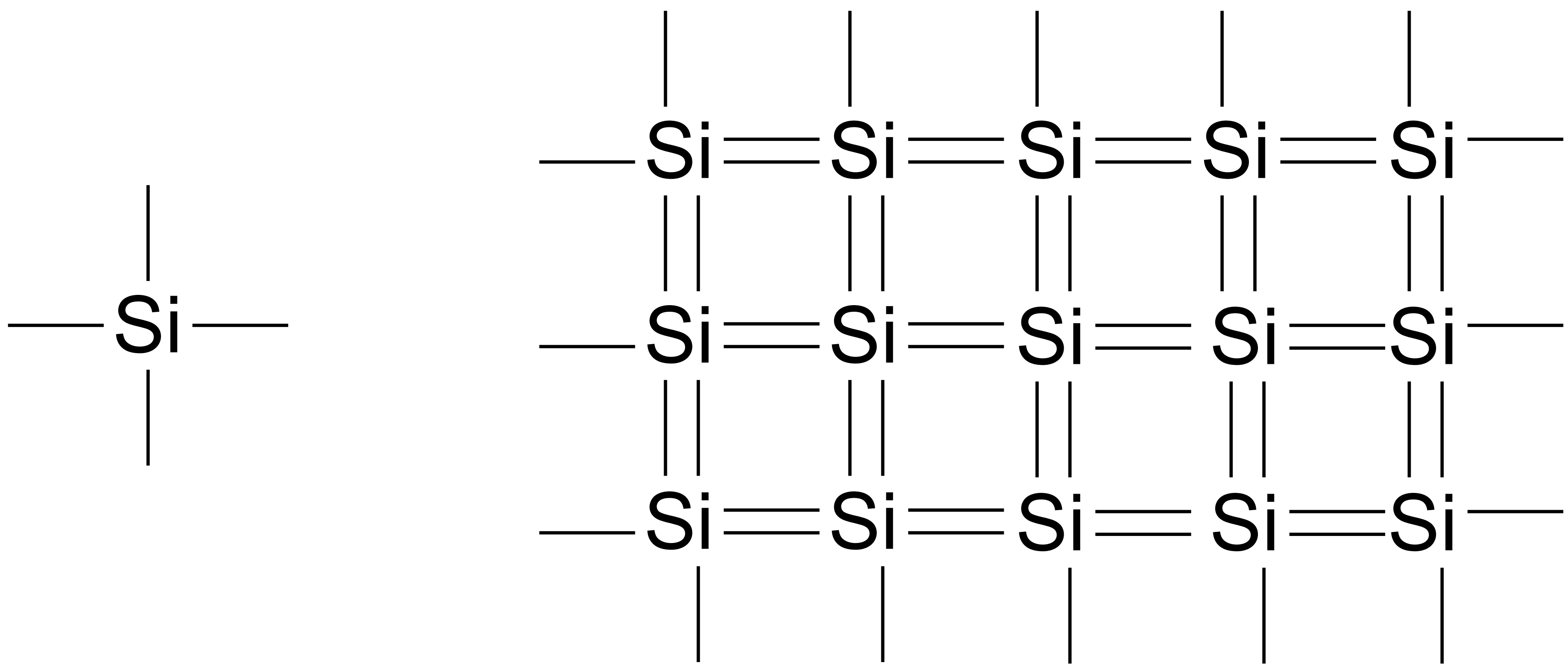
This current, together with the cell's built-in voltage, gives the power that the solar cell can produce.

Silicon, like carbon, has some unique properties since its outer electron shell is half-full (or half-empty) with 4 electrons.



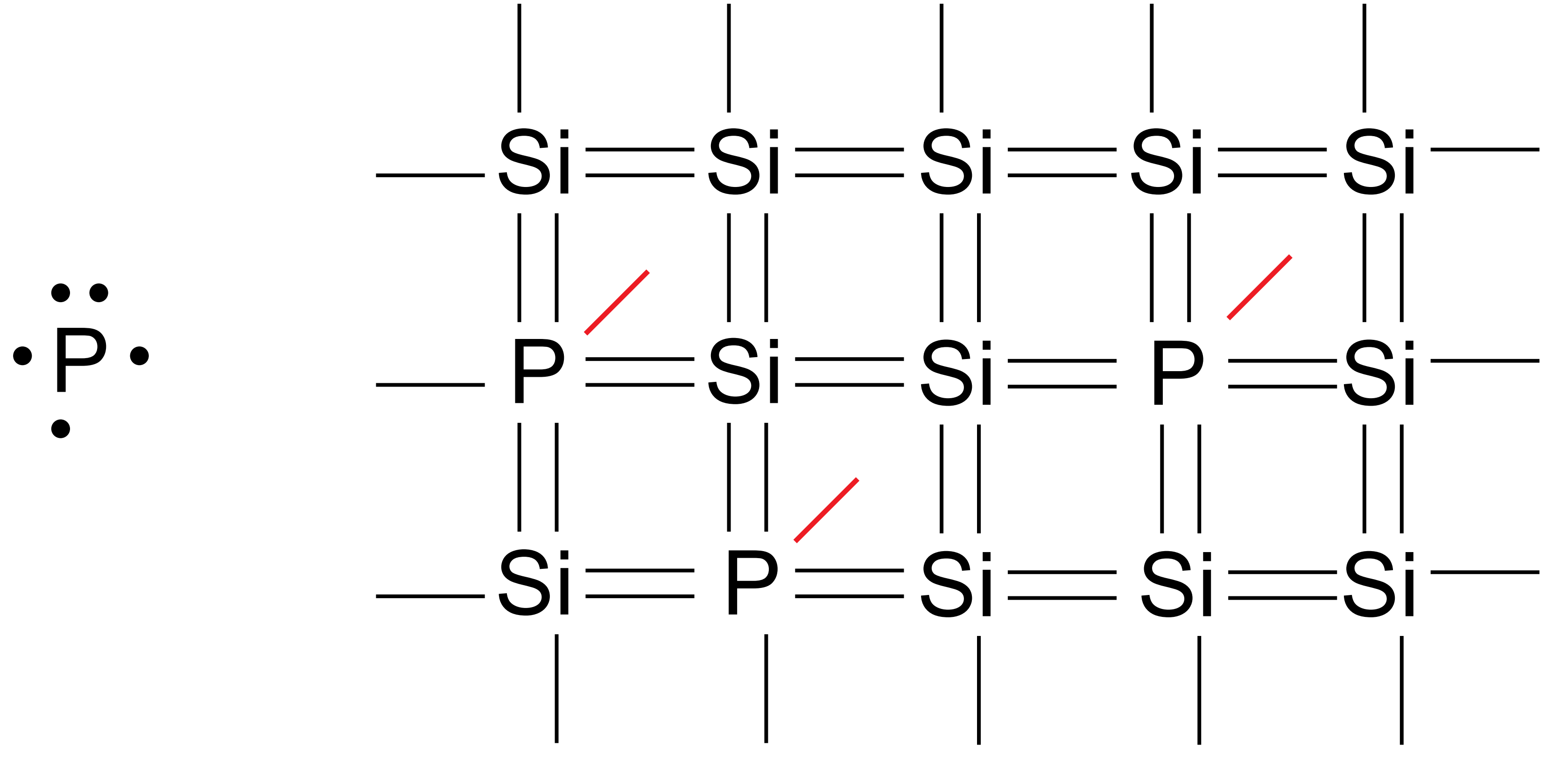
A silicon atom will always look for ways to fill up its last shell, and to do this, it will share electrons with four nearby atoms. This is what forms the pure silicon crystalline structure.

When energy is added to pure silicon, say in the form of light, it can cause a few electrons to break free of their bonds and leave their atoms. A hole is left behind in each case.



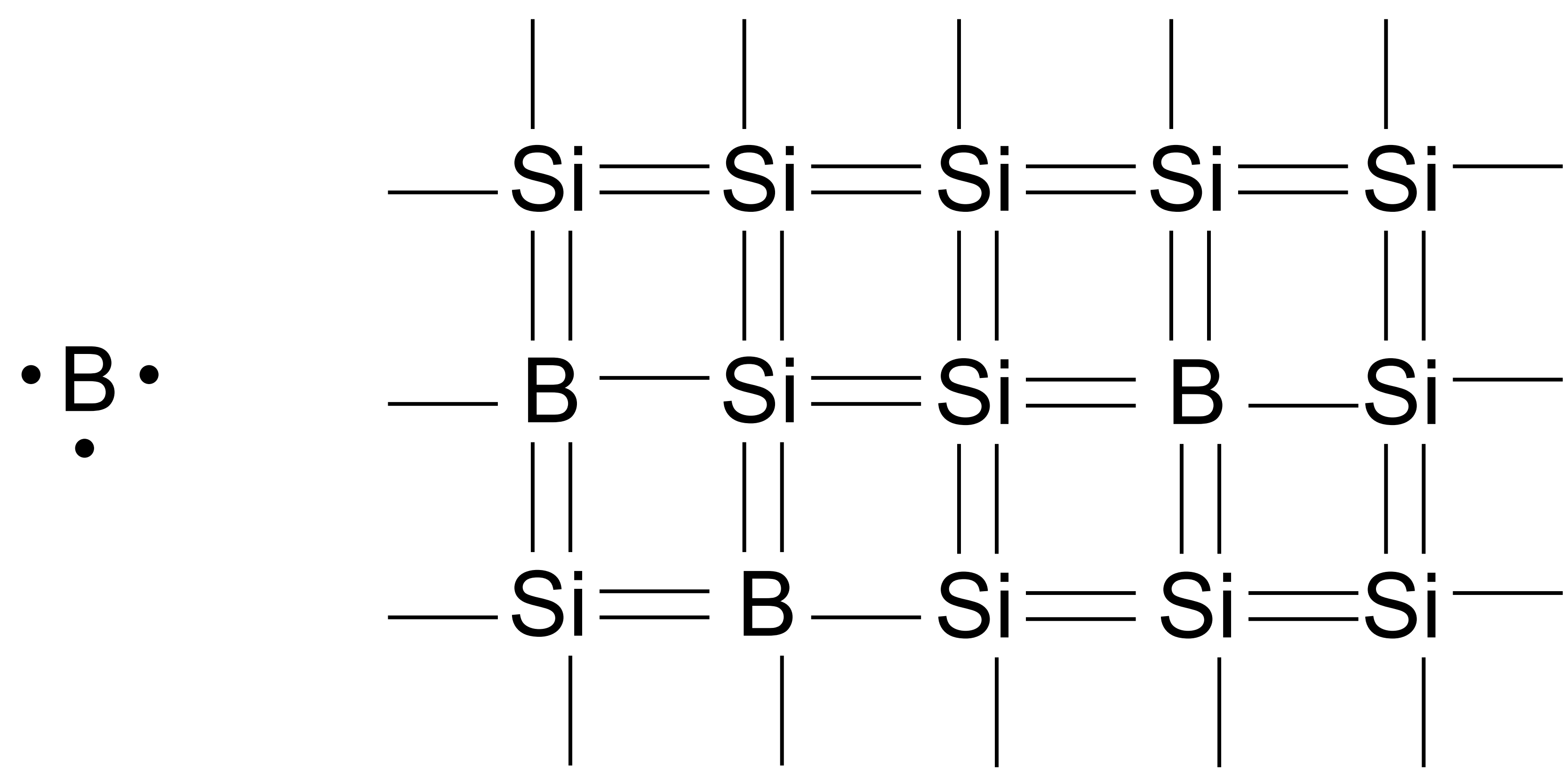
These free electrons then wander around the lattice looking for another hole to fall into, and thus carry a current. But, there are so few free electrons that they aren't very useful.

Consider a Si lattice with an atom of phosphorous here and there, maybe one for every million Si atoms. P has five electrons in its outer shell. It still bonds with its Si neighbors, but has one extra electron that doesn't bond.



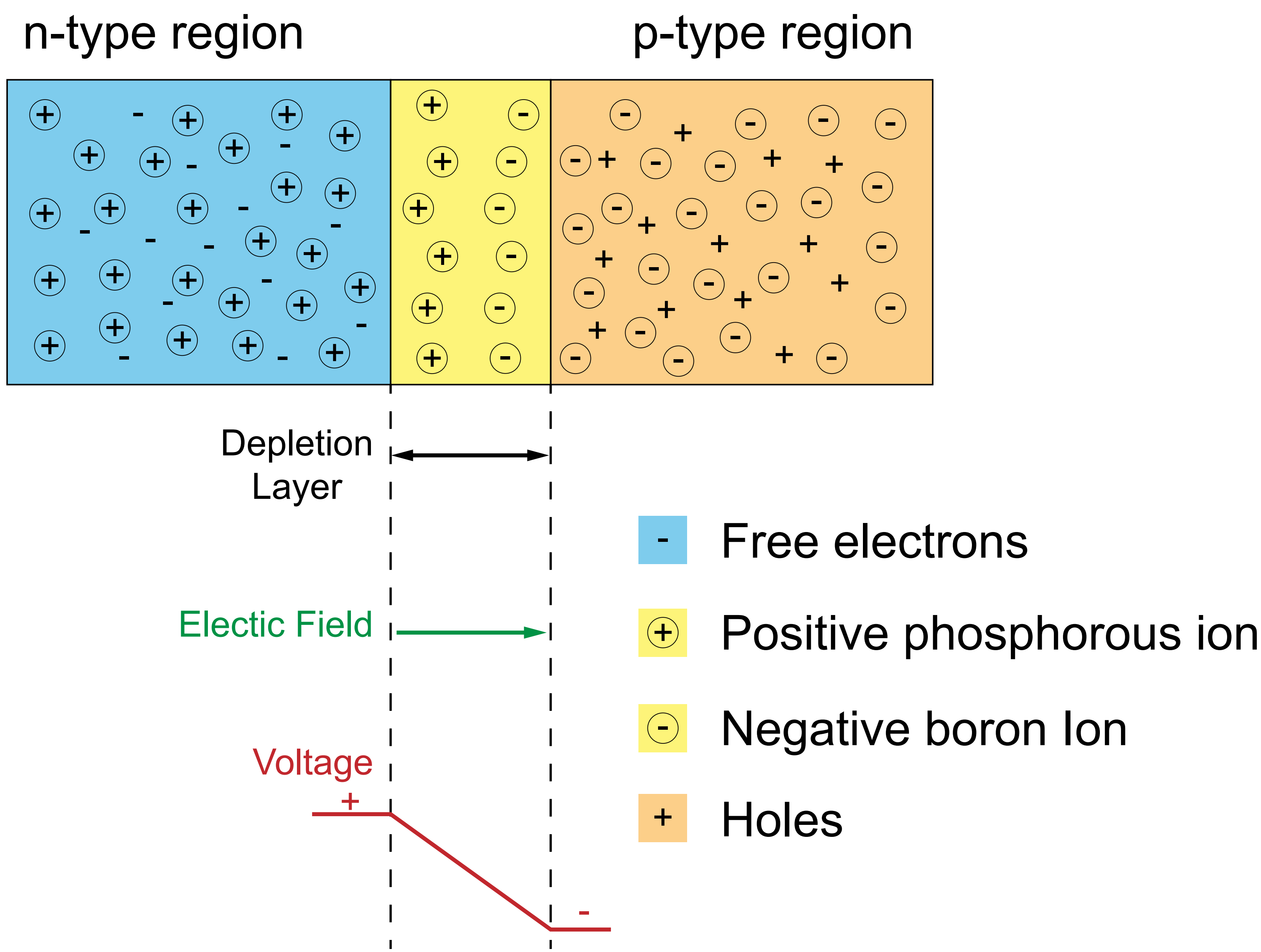
Silicon with such impurities is called "n-type", with the "n" signifying the negatively charged electron.

Boron has three electrons in its outer shell. It still bonds with its silicon neighbors, but one bond is missing an electron.



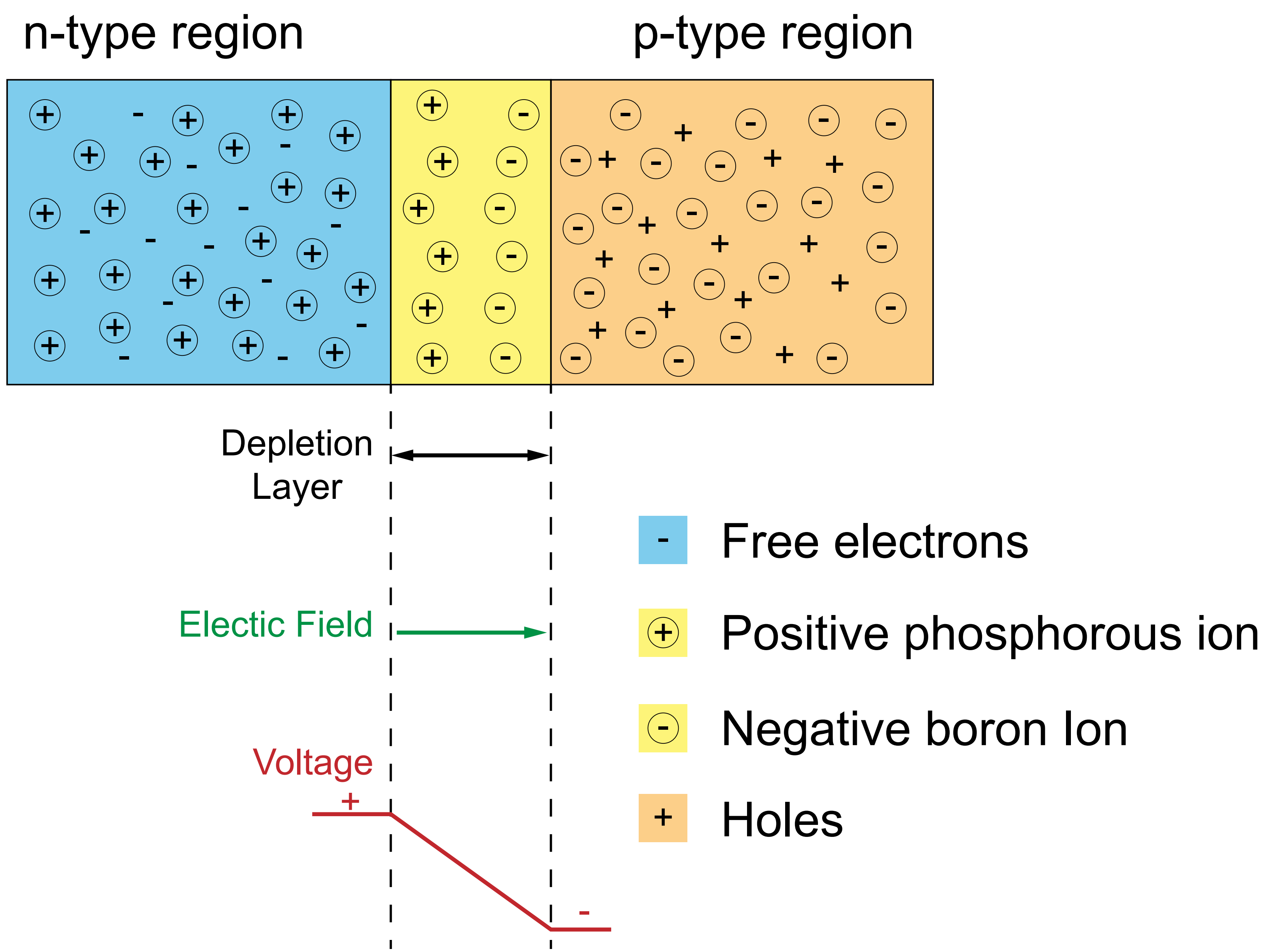
Silicon with such impurities is called "p-type", with the "p" signifying the extra positively charged openings (holes).

The cool part begins when you put the n-type and p-type semiconductors in physical contact with each other.



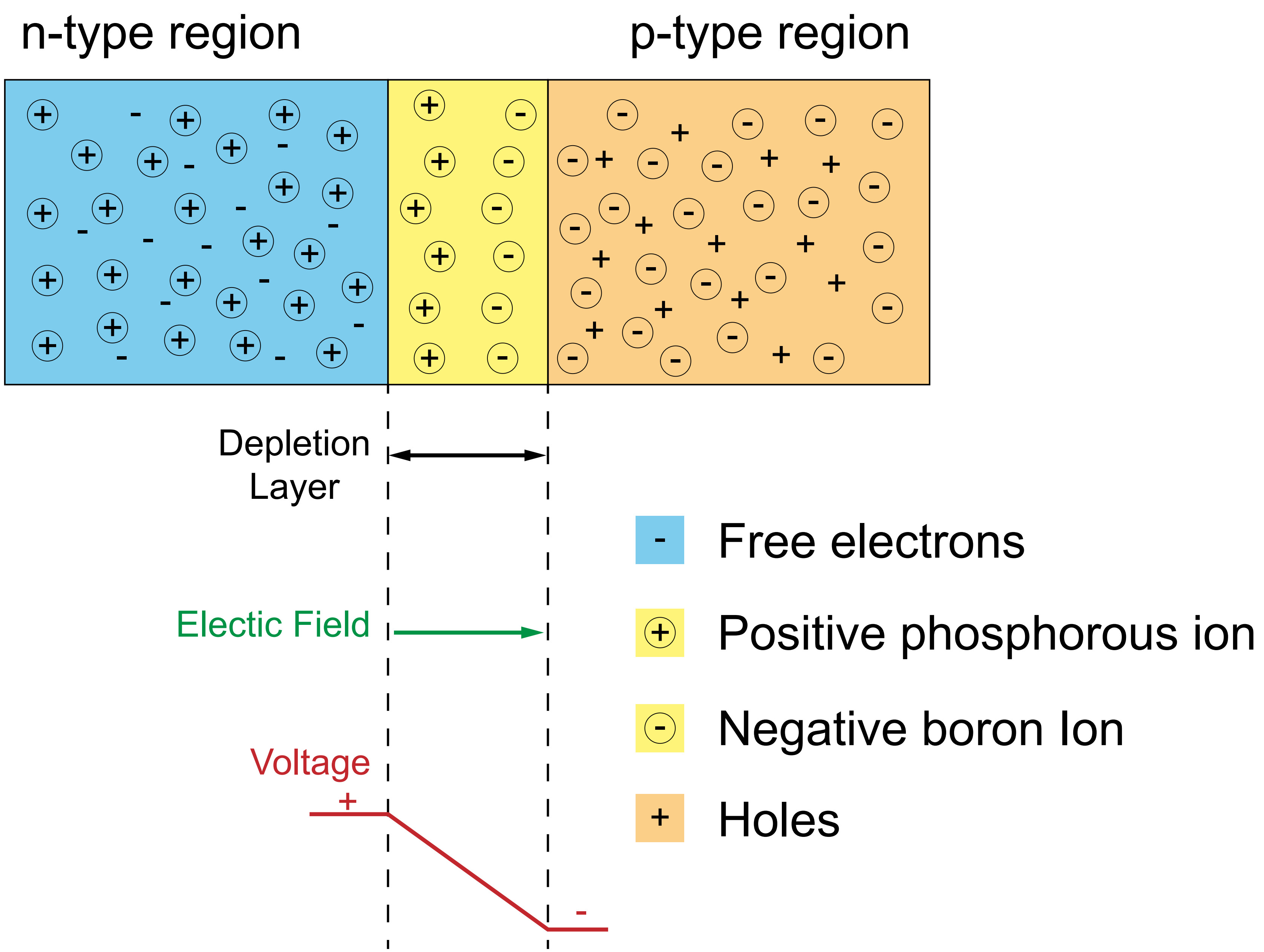
The free electrons on the N side see all the openings on the P side, and there's a mad rush to fill them.

At the PN-junction they combine and in the process form a barrier, making it harder and harder for additional electrons on the N side to cross over to the P side to find a hole.



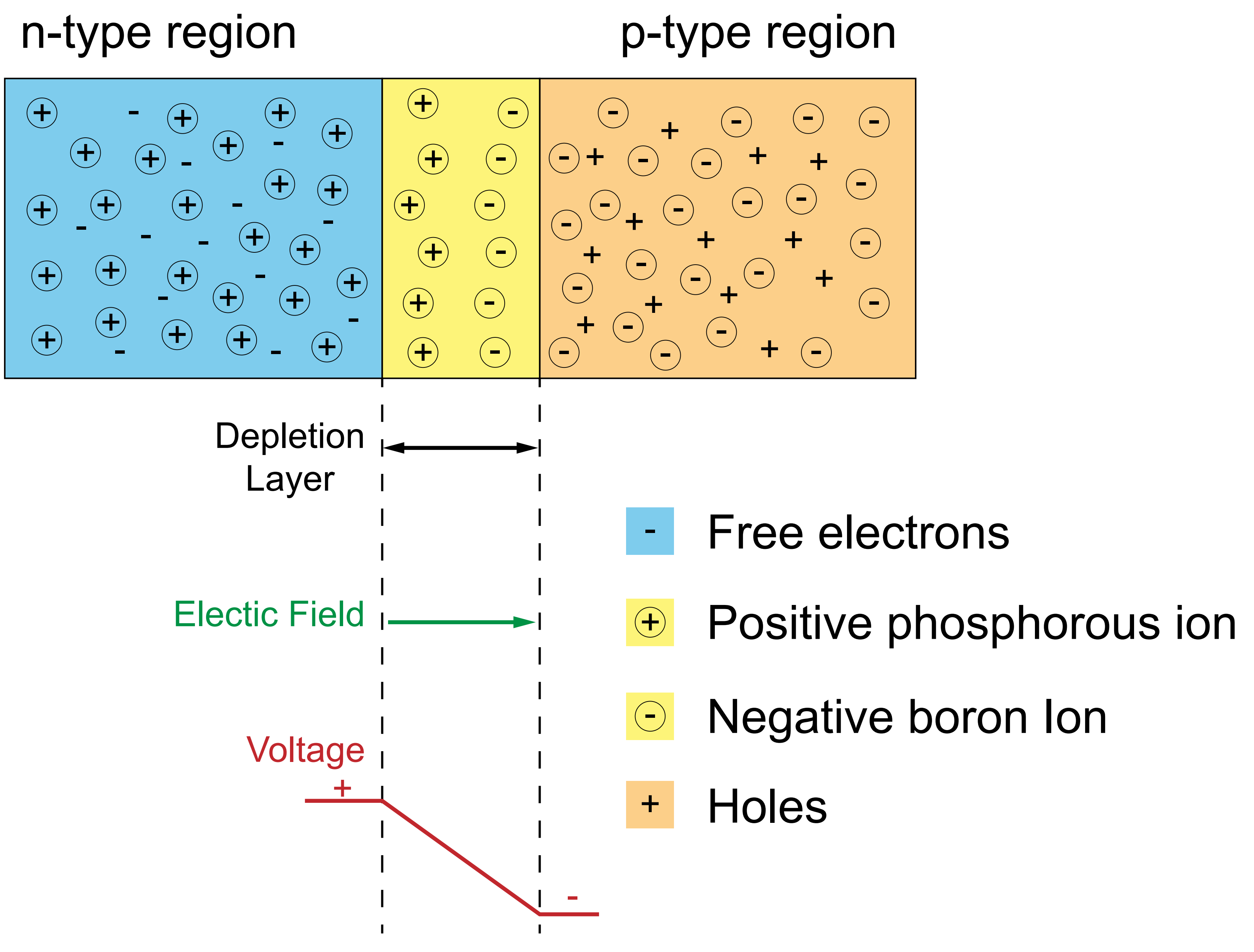
Eventually, equilibrium is reached, and we have an electric field separating the two sides.

The device acts as a diode, allowing electrons to flow from the P side to the N side, but not the other way around.



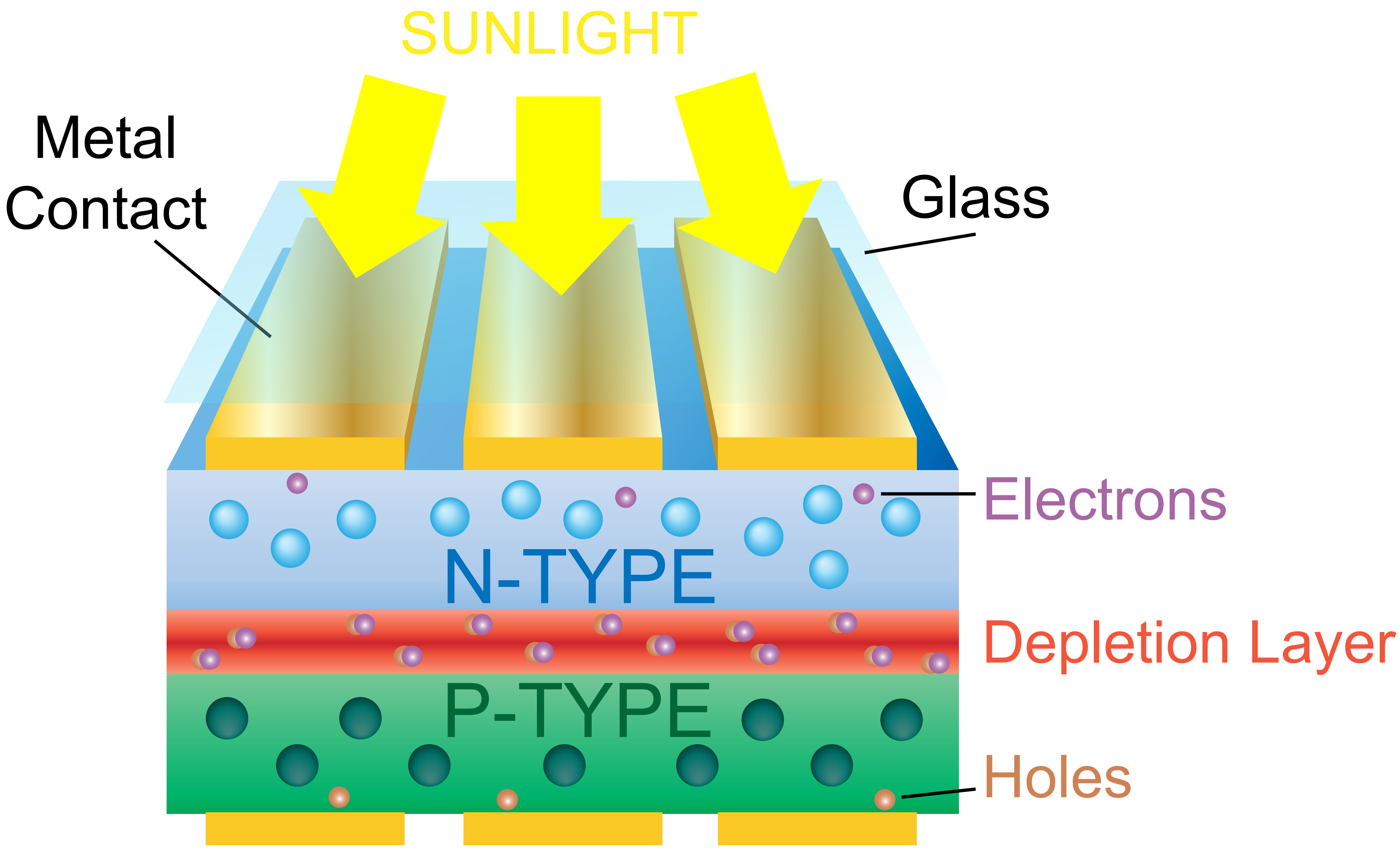
It's like a hill - electrons can easily go down the hill (to the N side), but can't climb it (to the P side).

When a photon hits the electrically neutral depletion layer its energy normally breaks one bond and frees one electron.

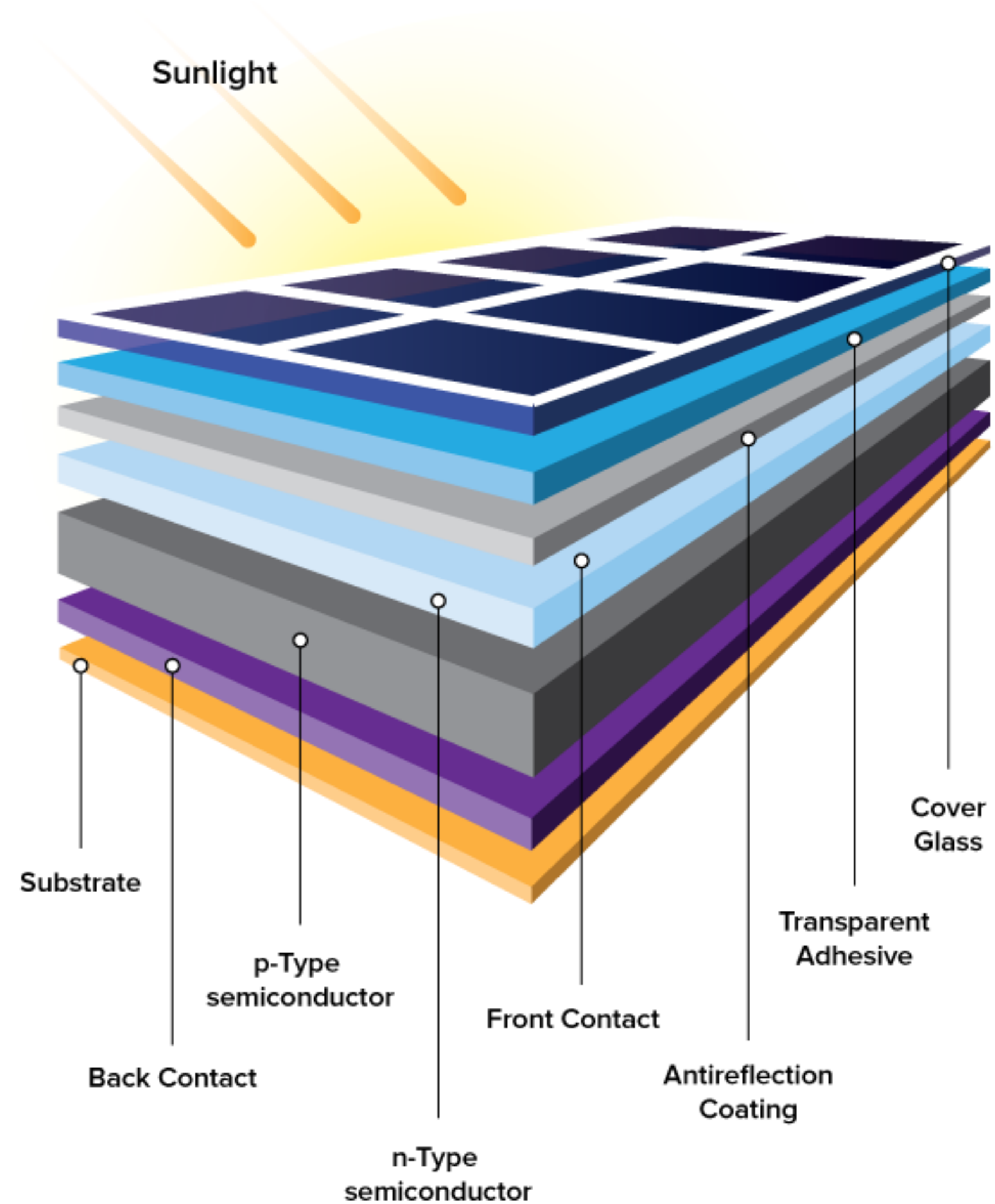


If this happens close to the built-in electric field, the field will send the electron to the N side and the hole to the P side.

If we provide an external current path, electrons will flow through the path to the P side to unite with holes that the electric field sent there, doing work for us along the way.



The electron flow provides the DC current, and the cell's built-in electric field causes a voltage.



With both current and voltage, we have power, which is the product of the two.