SOLID-STATE PHYSICS: CONDUCTION

Prof. Stephen Sekula

(3/30/2010)

Supplementary Material for

PHY 3305 (Modern Physics)

Harris, Ch. 10.6-10.8

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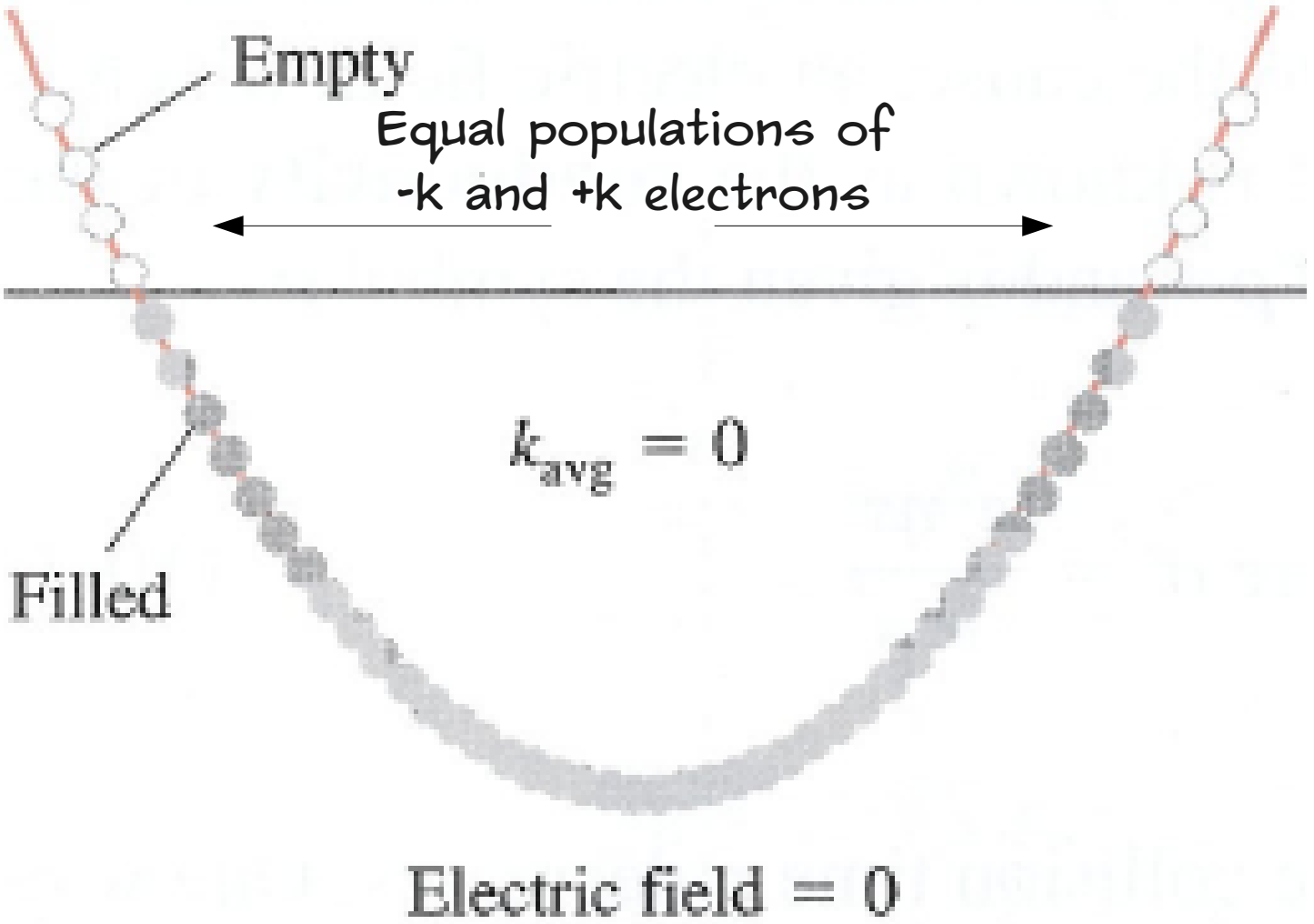
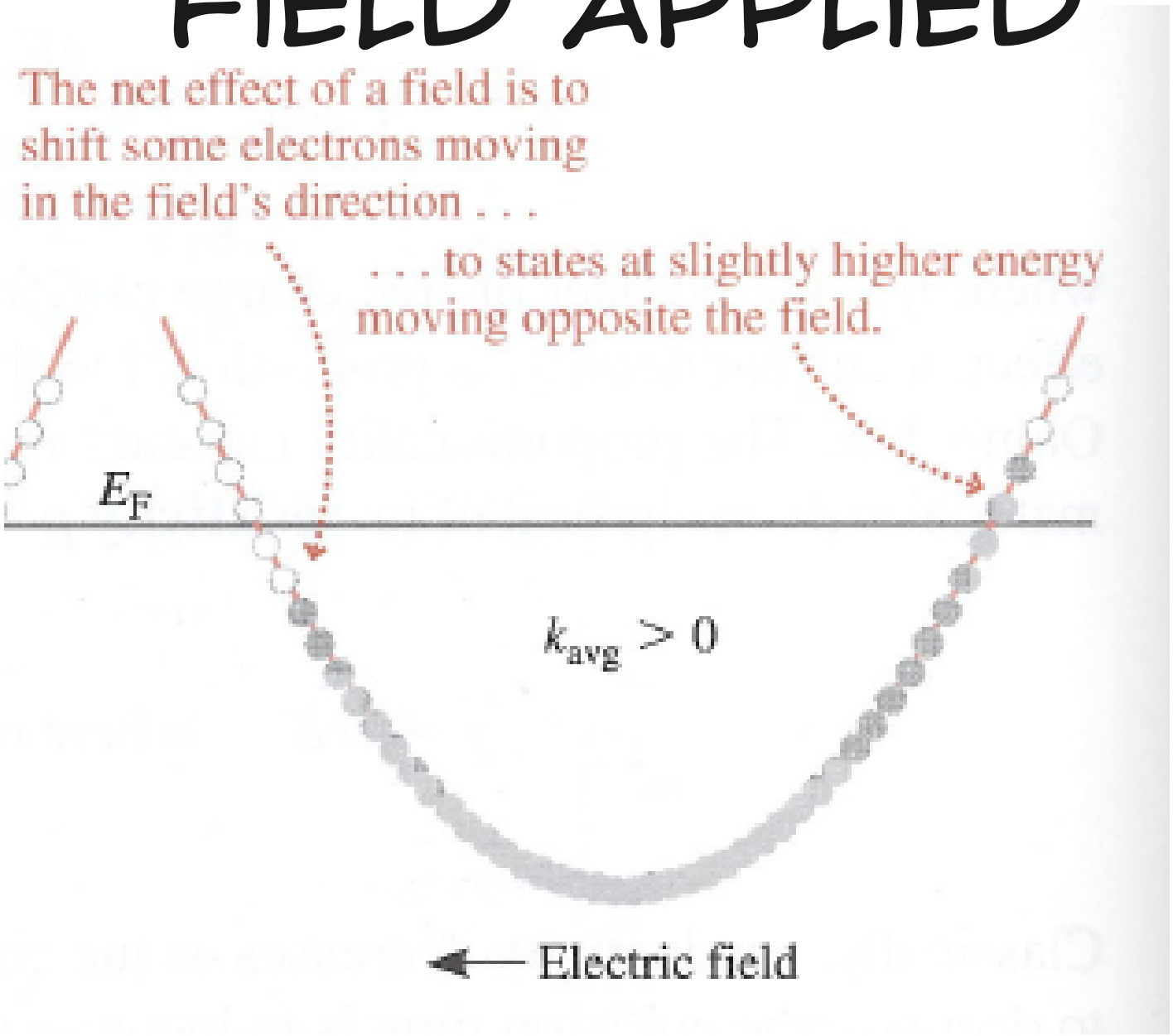
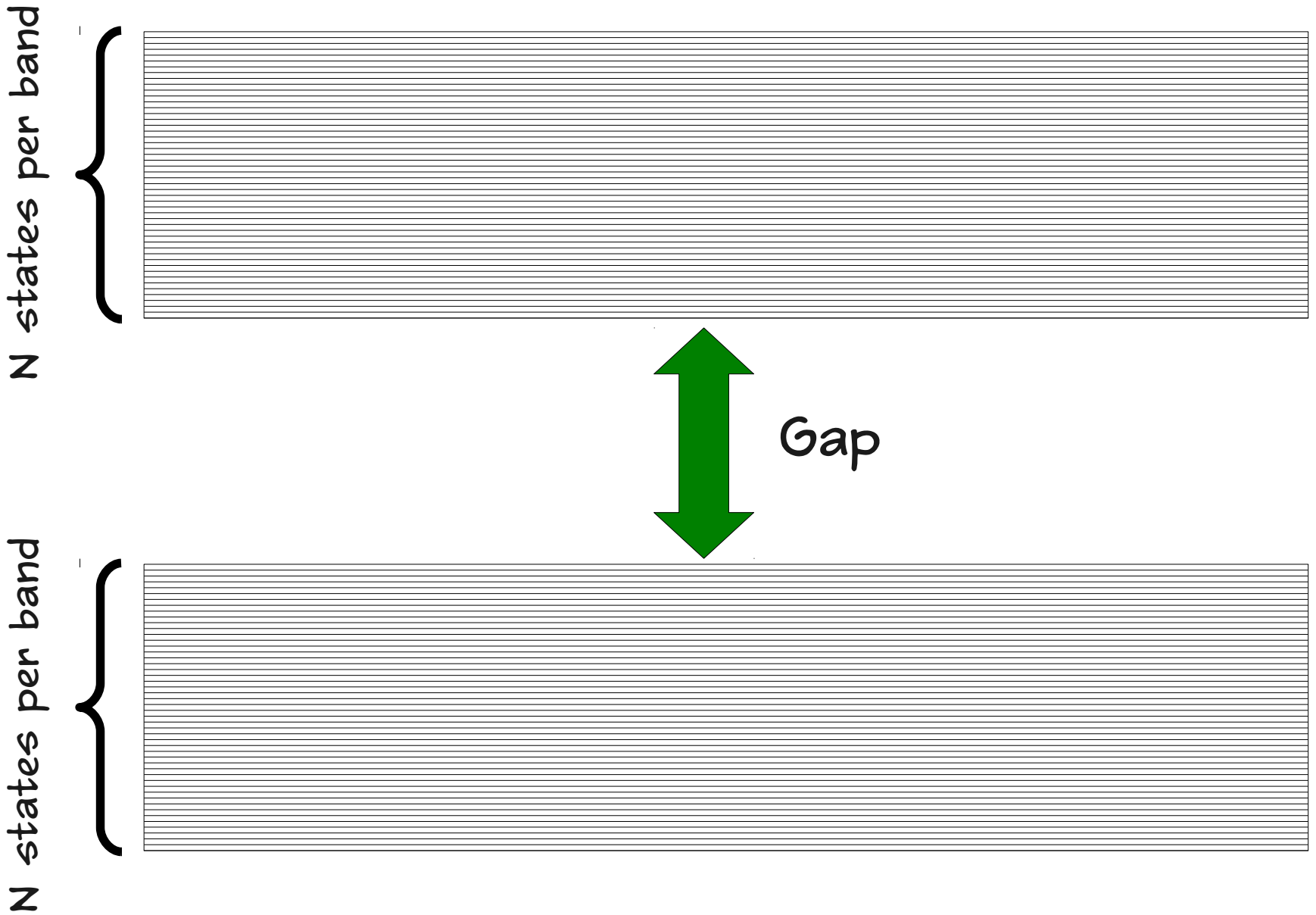
SOLID, NO ELECTRIC FIELD APPLIED



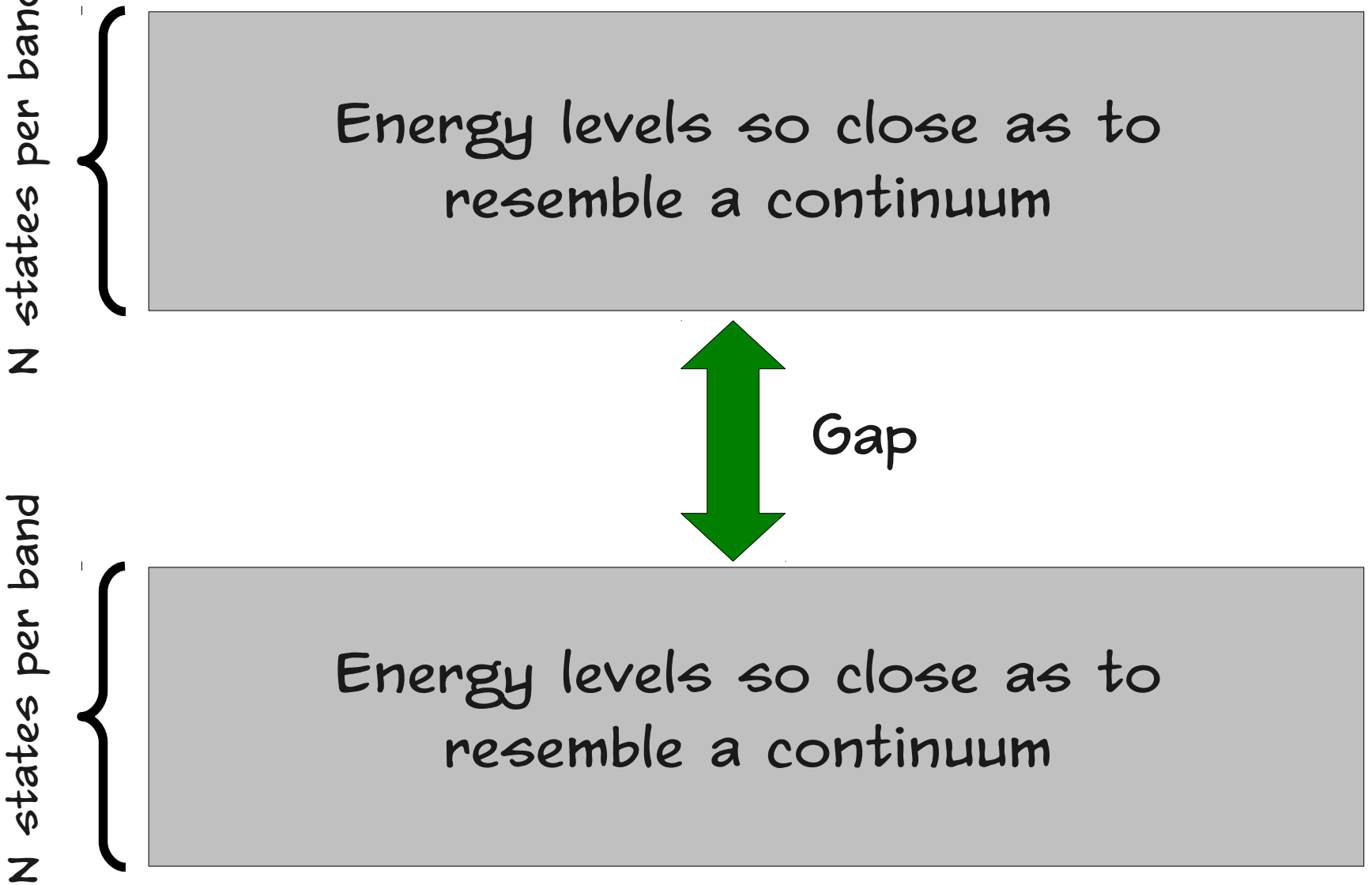
SOLID, WITH ELECTRIC FIELD APPLIED



A PICTURE: BANDS/GAPS

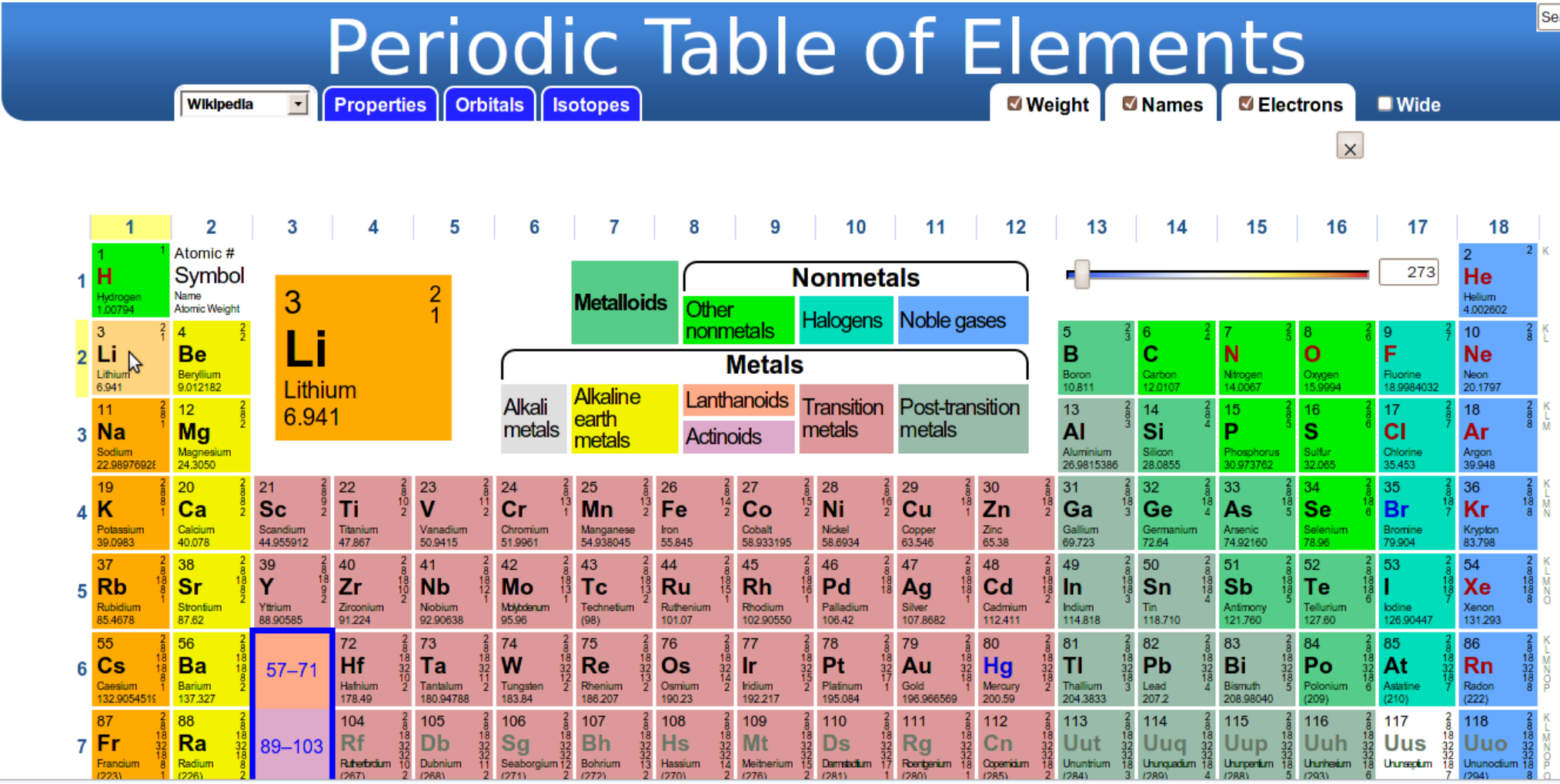


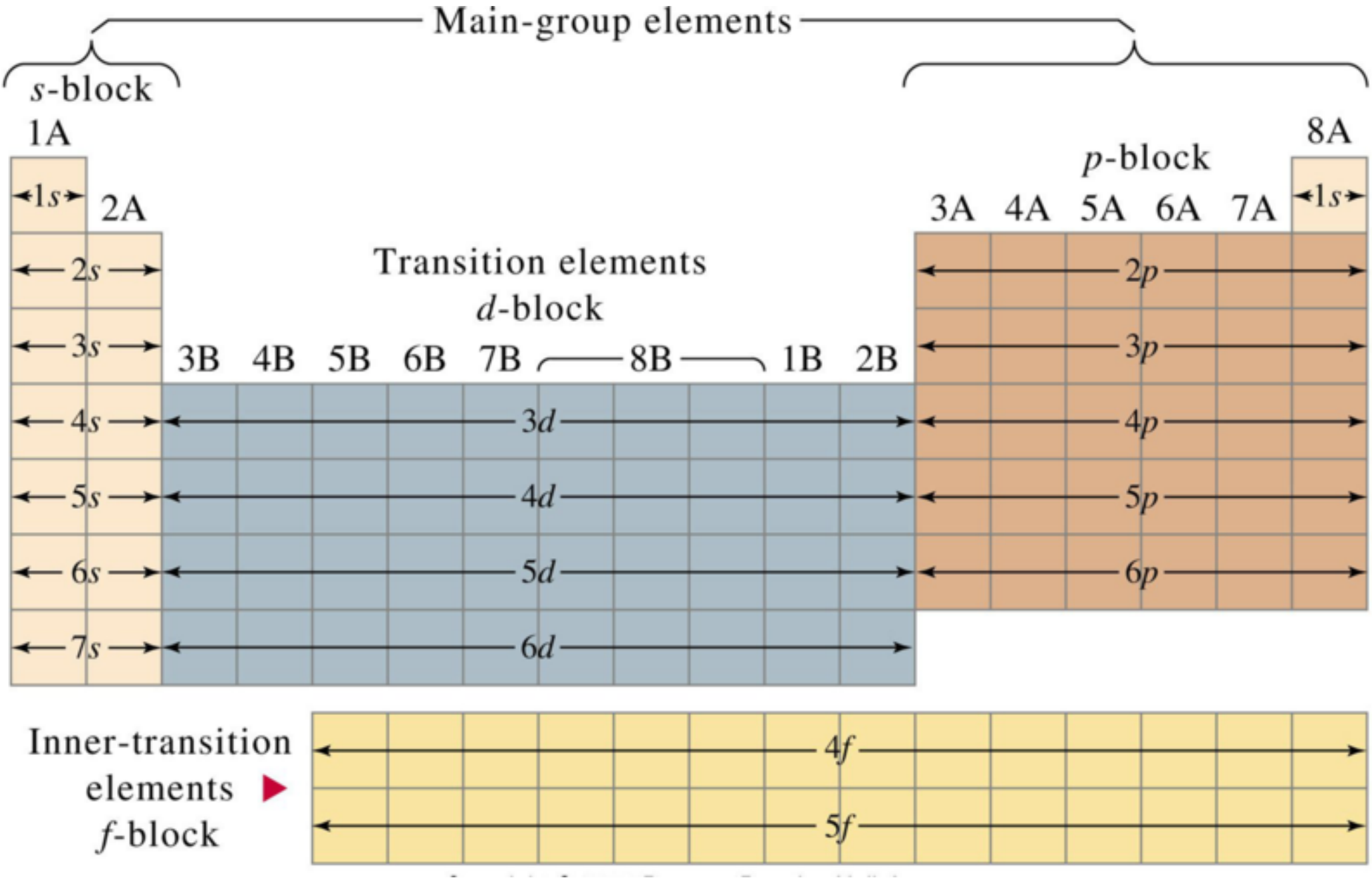
A PICTURE: BANDS/GAPS



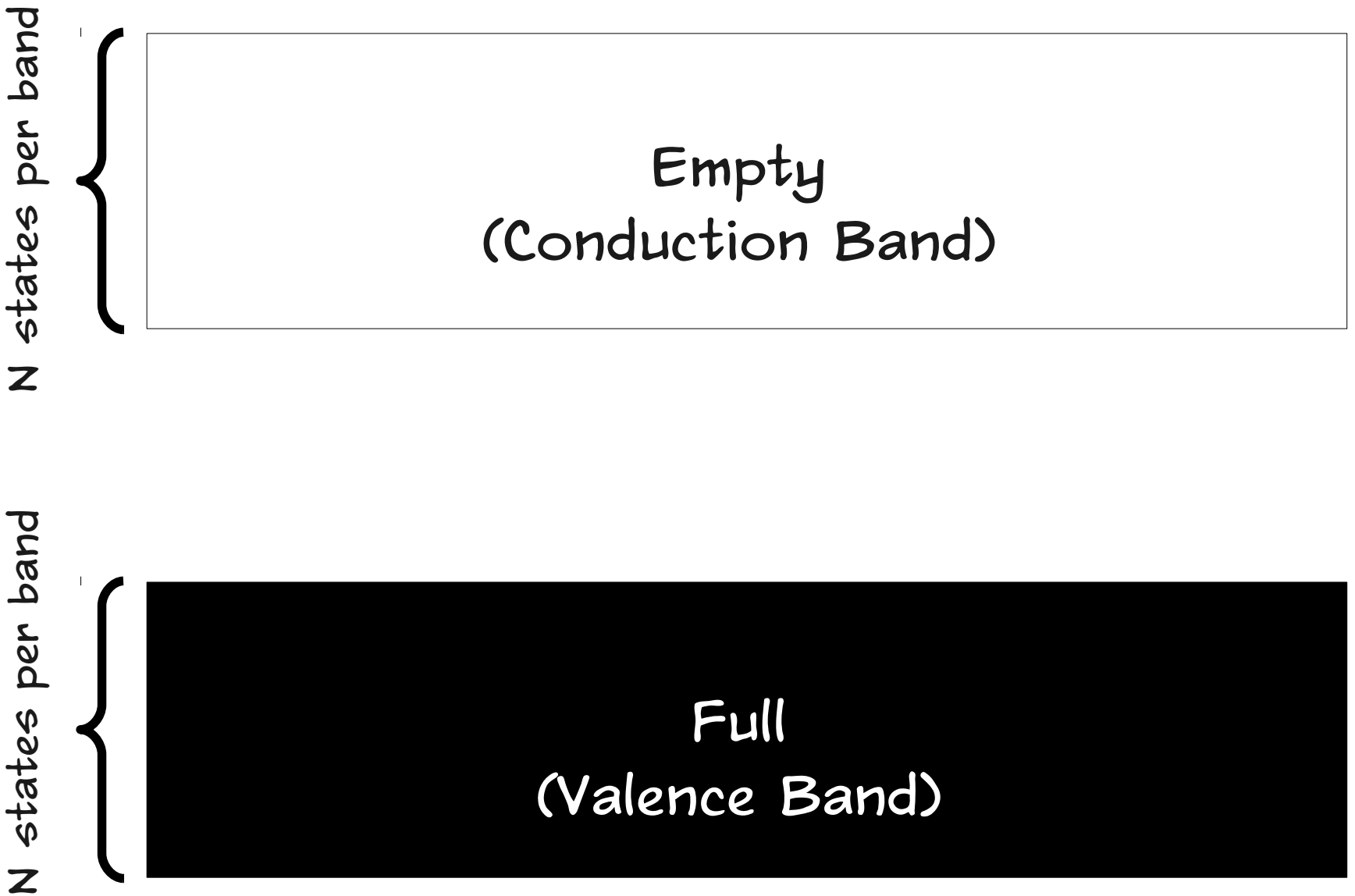
QUESTIONS

- How many conduction electrons can each band hold?
- Which is a better conductor: Lithium or Beryllium?
  - Lithium has 3 electrons
  - Beryllium has 4 electrons

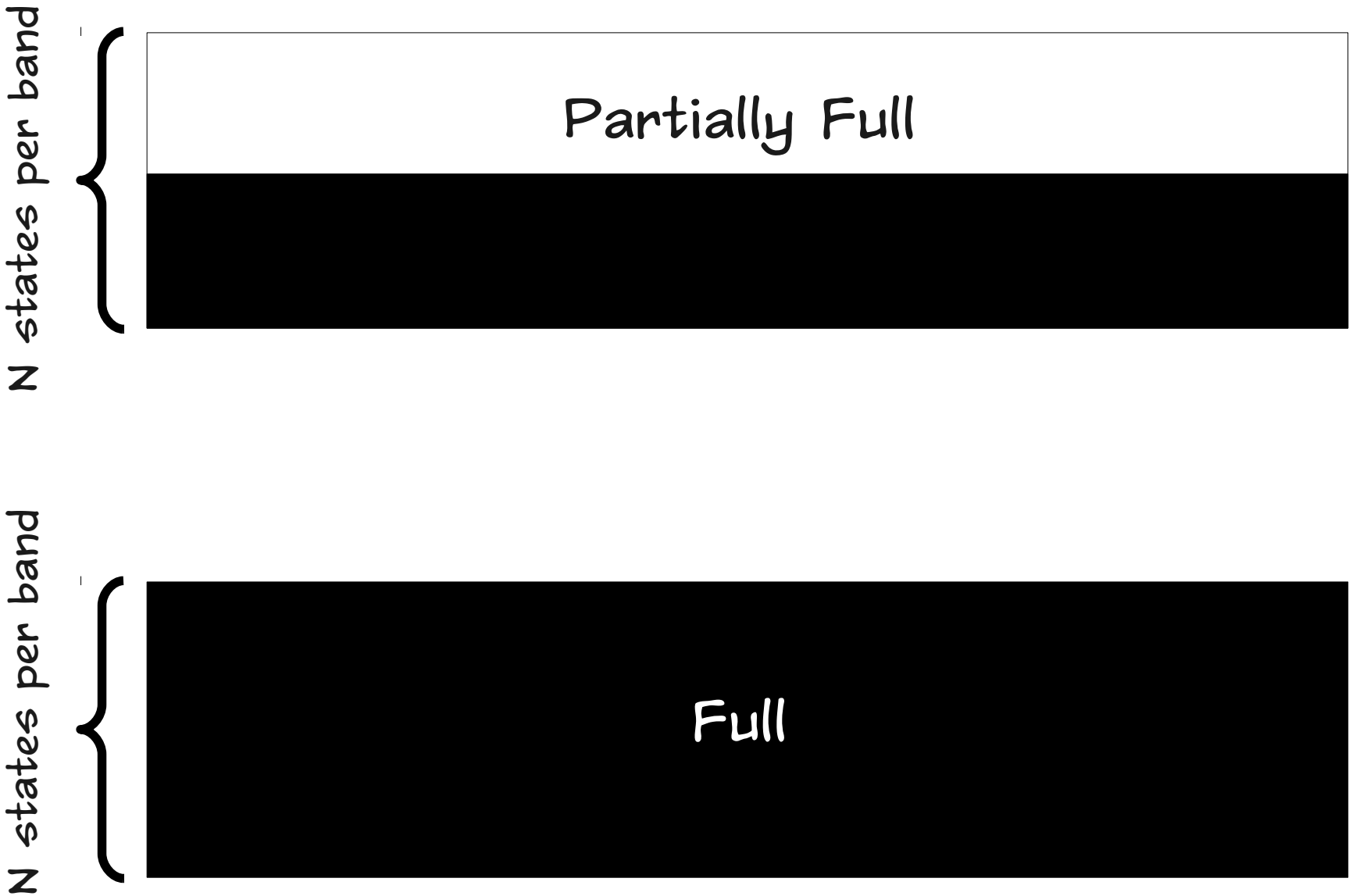

Periodic Table of Elements
Search
Wikipedia
Properties
Orbitals
Isotopes
Weight
Names
Electrons
Wide
Atomic #
Symbol
Name
Atomic Weight
3
Li
Lithium
6.941
Metalloids
Nonmetals
Other nonmetals
Halogens
Noble gases
Metals
Alkali metals
Alkaline earth metals
Lanthanoids
Actinoids
Transition metals
Post-transition metals
273
57–71
89–103


Main-group elements
s-block
1A
8A
p-block
1s
2A
3A
4A
5A
6A
7A
1s
2s
2p
Transition elements
d-block
3s
3p
3B
4B
5B
6B
7B
8B
1B
2B
4s
3d
4p
5s
4d
5p
6s
5d
6p
7s
6d
Inner-transition
elements
f-block
4f
5f

INSULATOR (T=0)

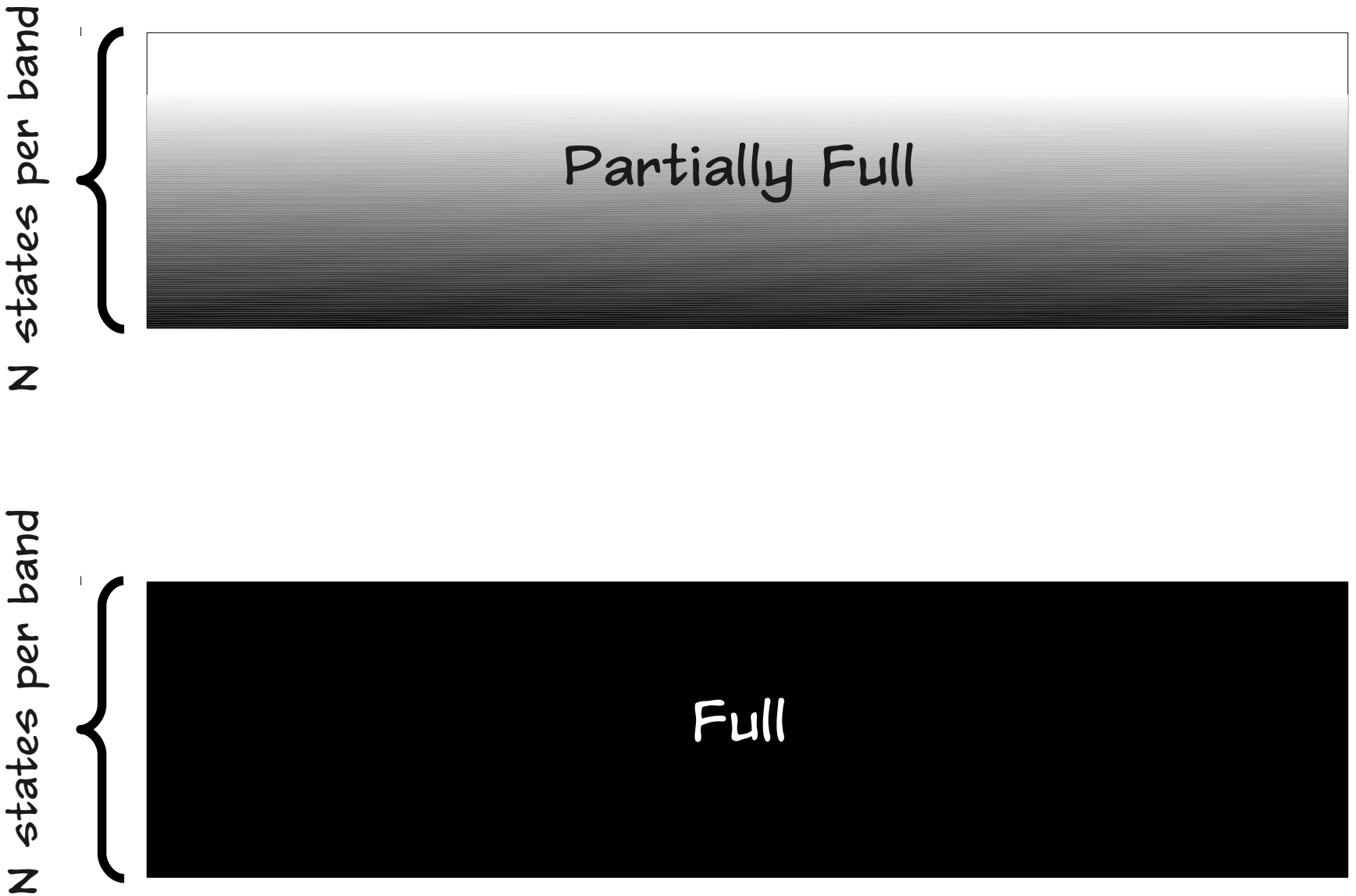


CONDUCTOR (T=0)

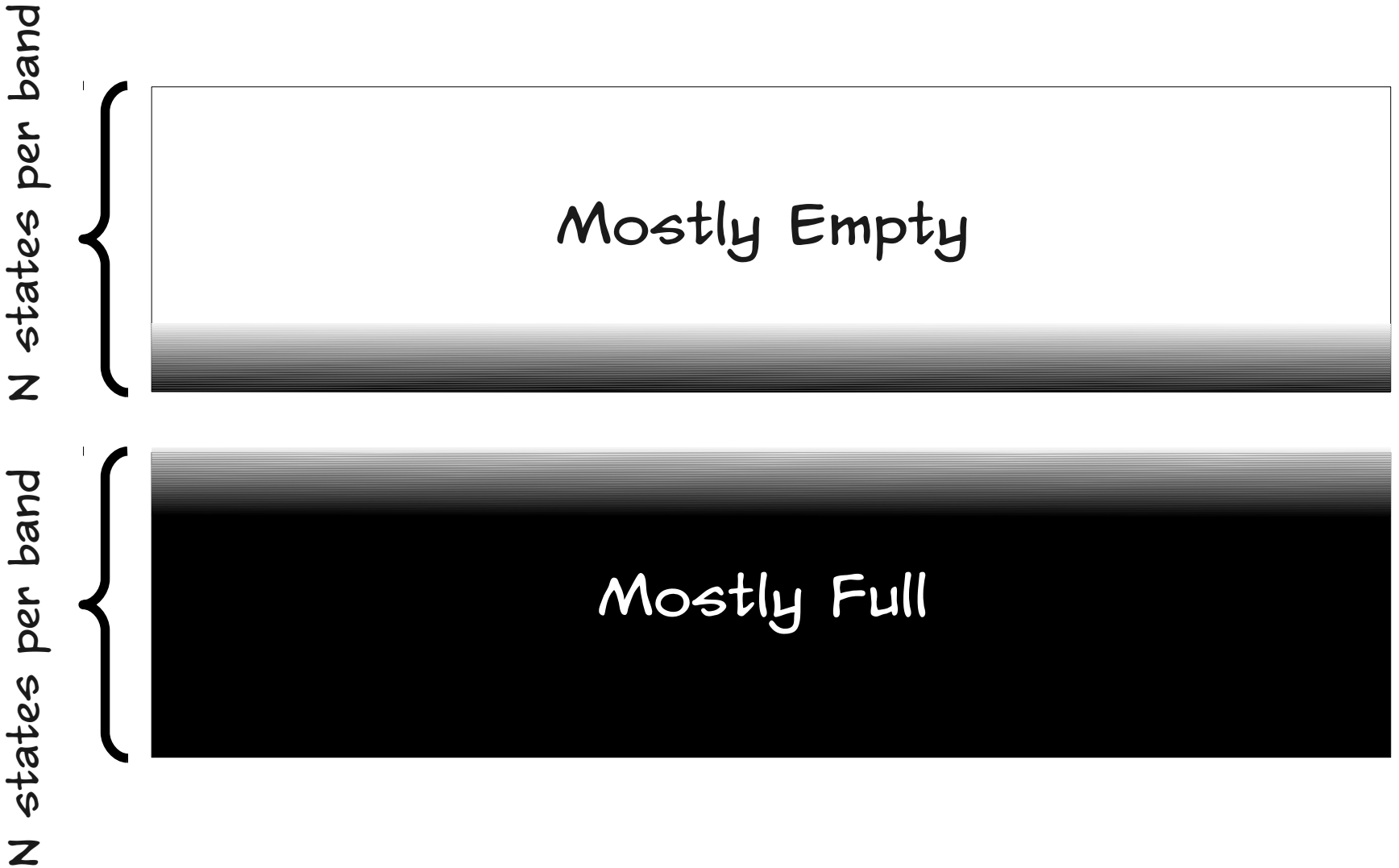


SEMI-CONDUCTOR (T=0)

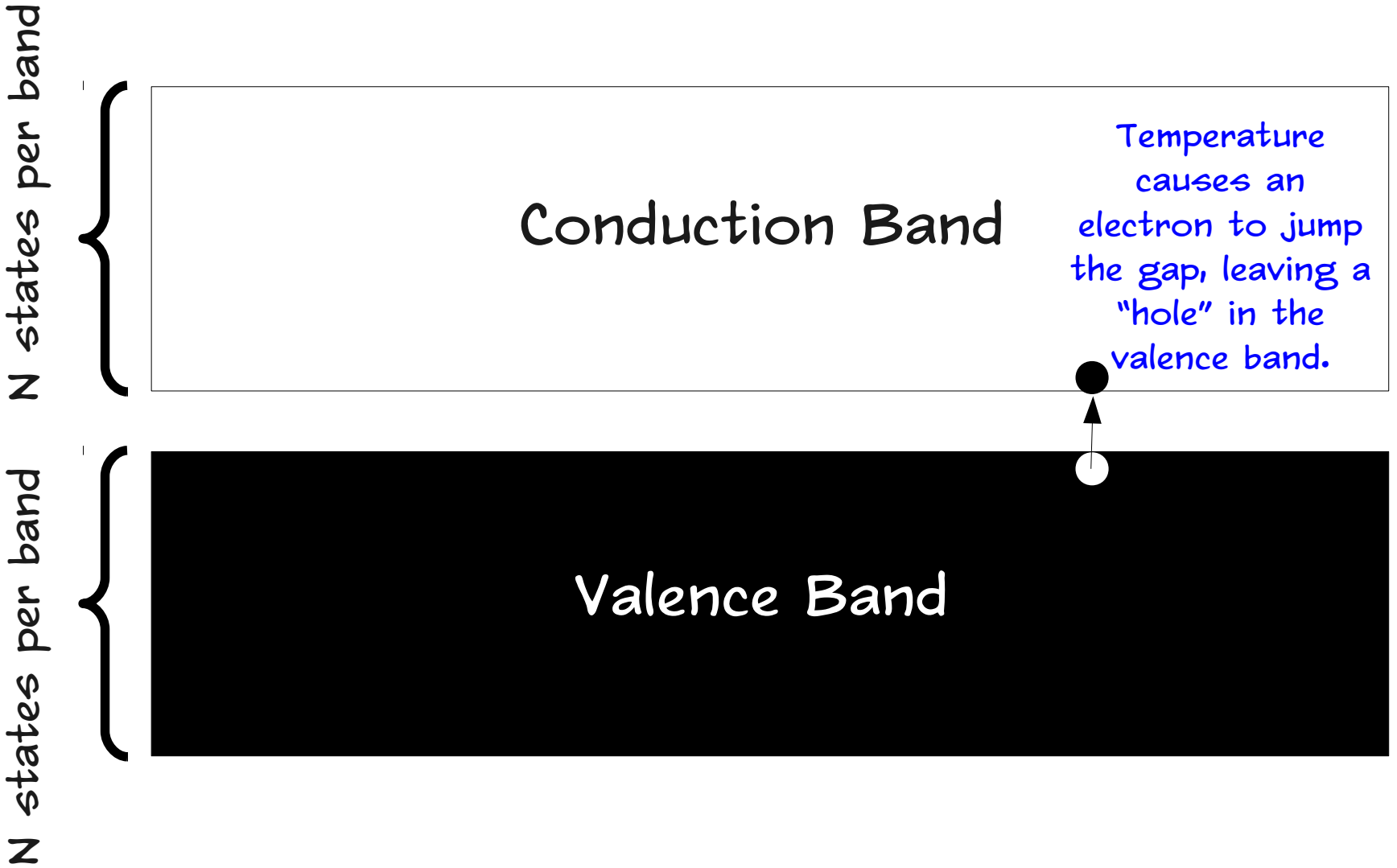
CONDUCTOR (T>0)



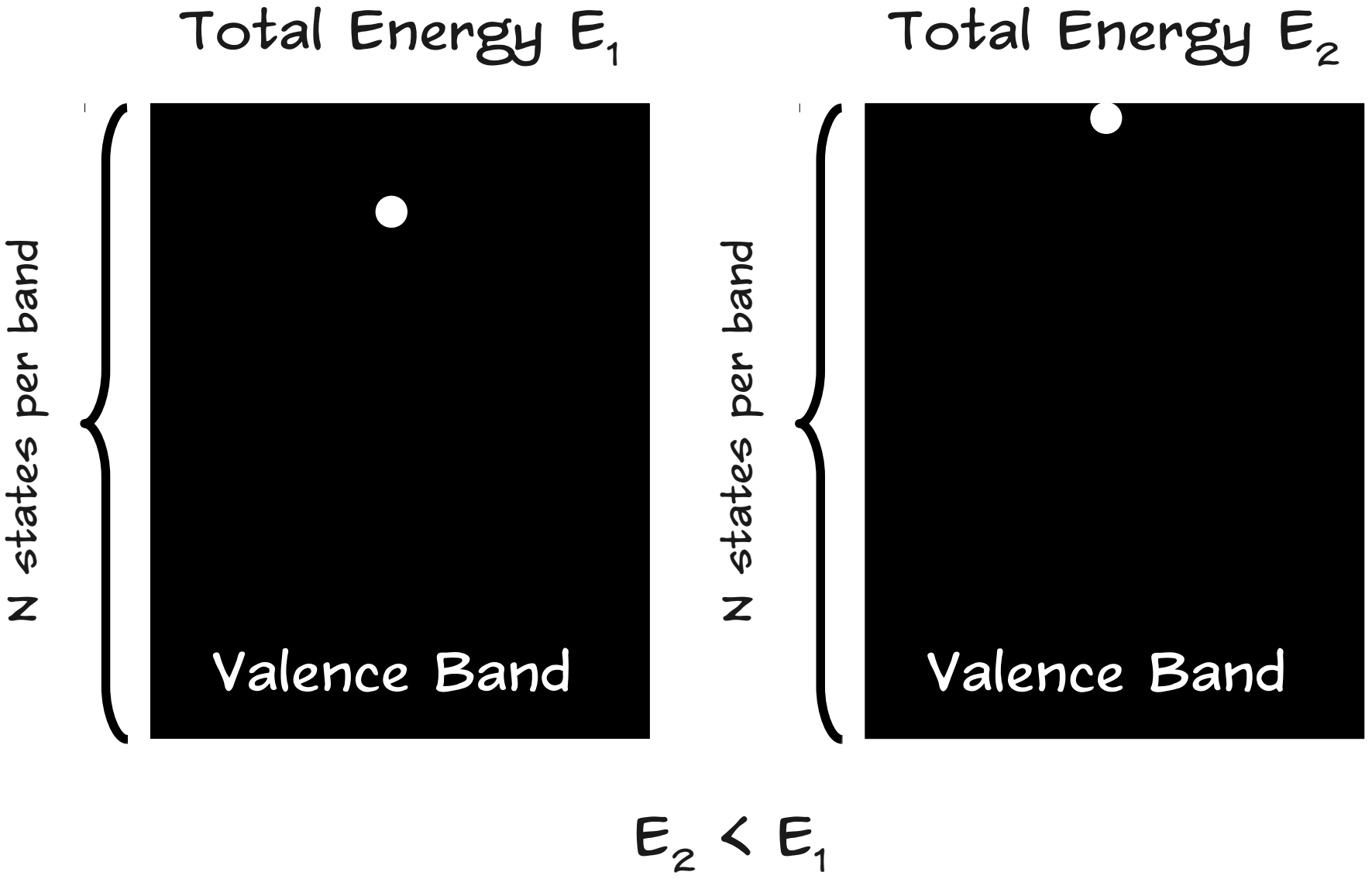
SEMI-CONDUCTOR (T>0)



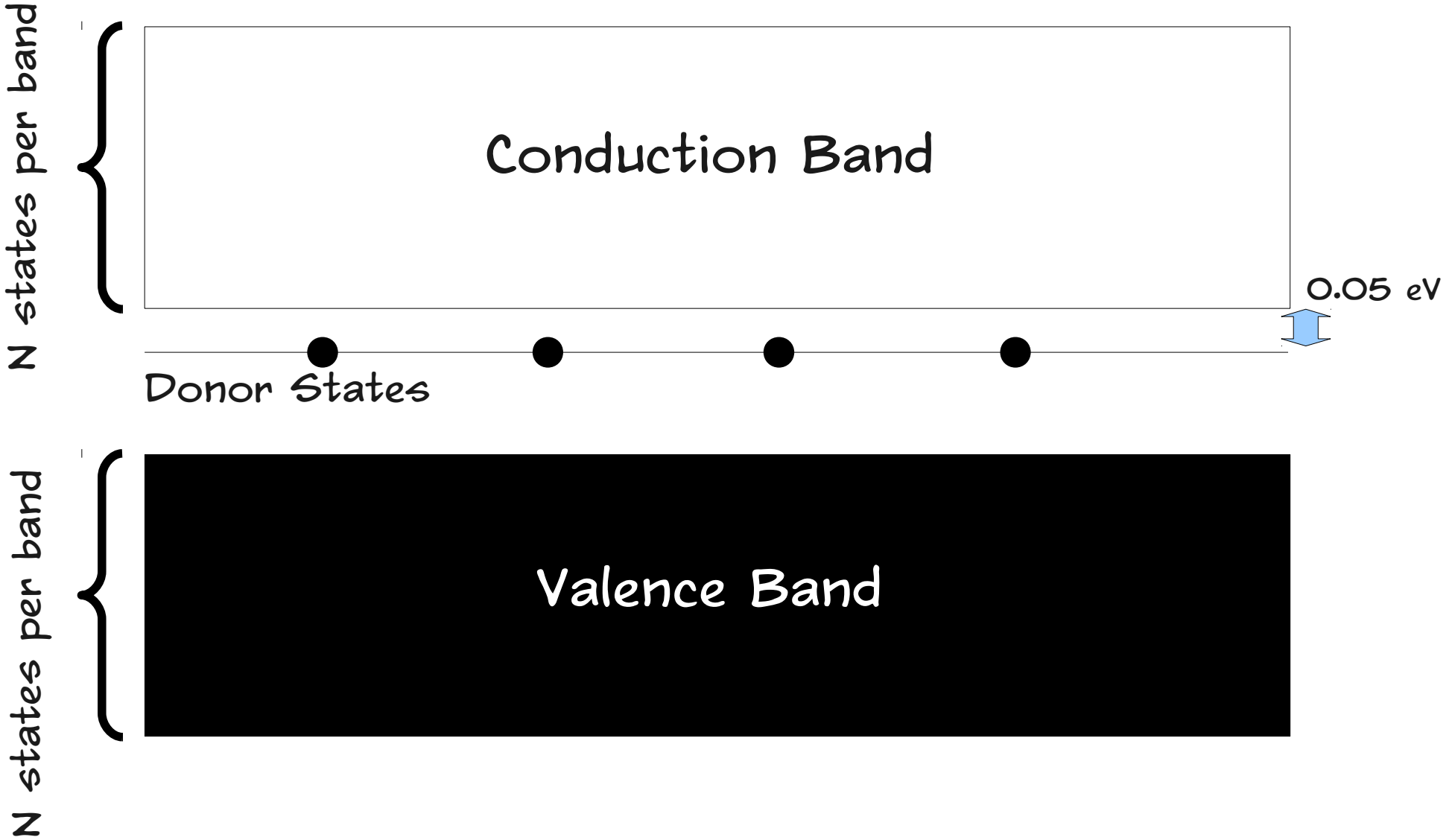
HOLES (T>0)


N states per band
Conduction Band
Temperature causes an electron to jump the gap, leaving a "hole" in the valence band.
N states per band
Valence Band

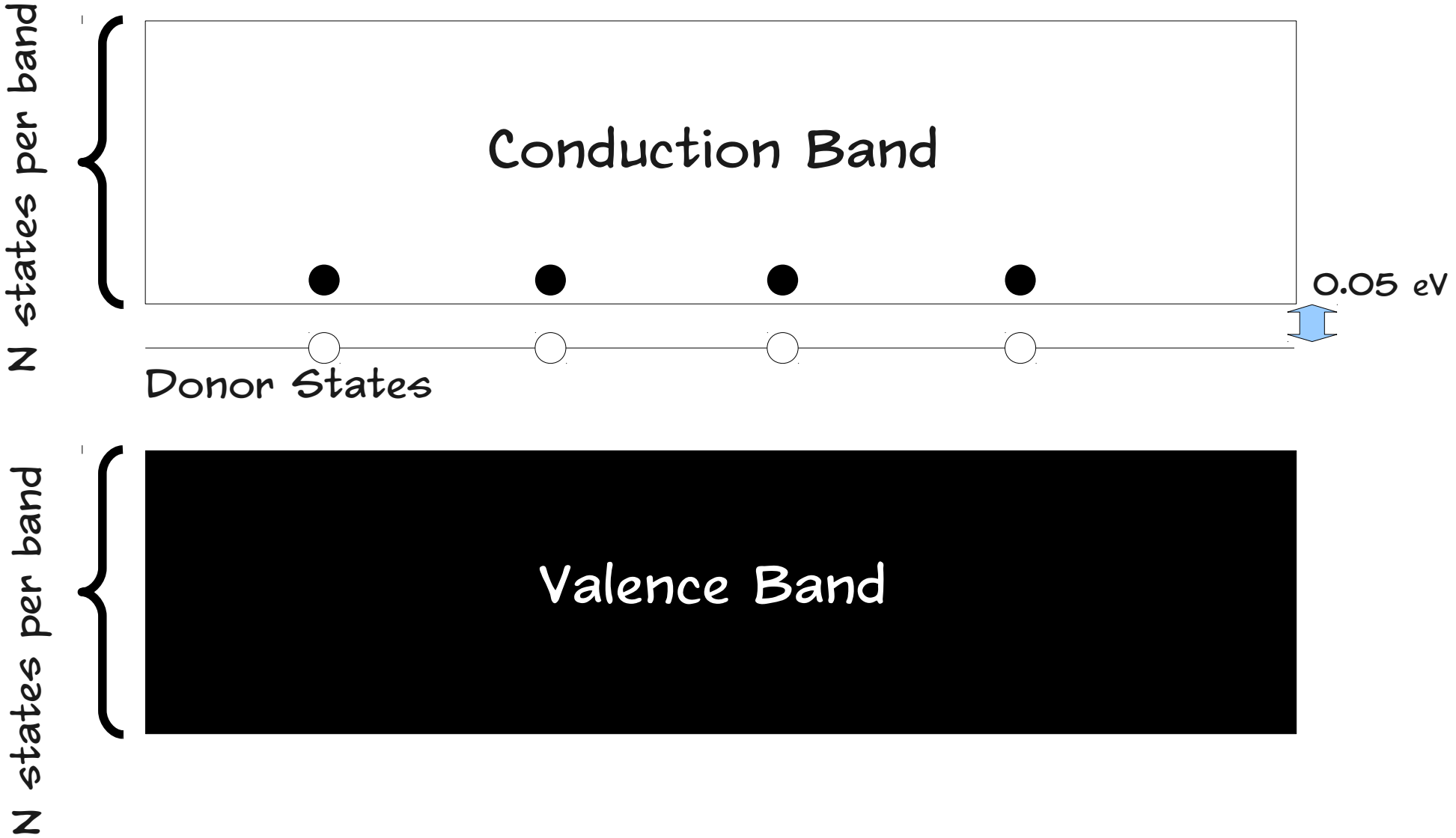
HOLES FLOAT


Total Energy E_1
Total Energy E_2
N states per band
N states per band
Valence Band
Valence Band
$E_2 < E_1$

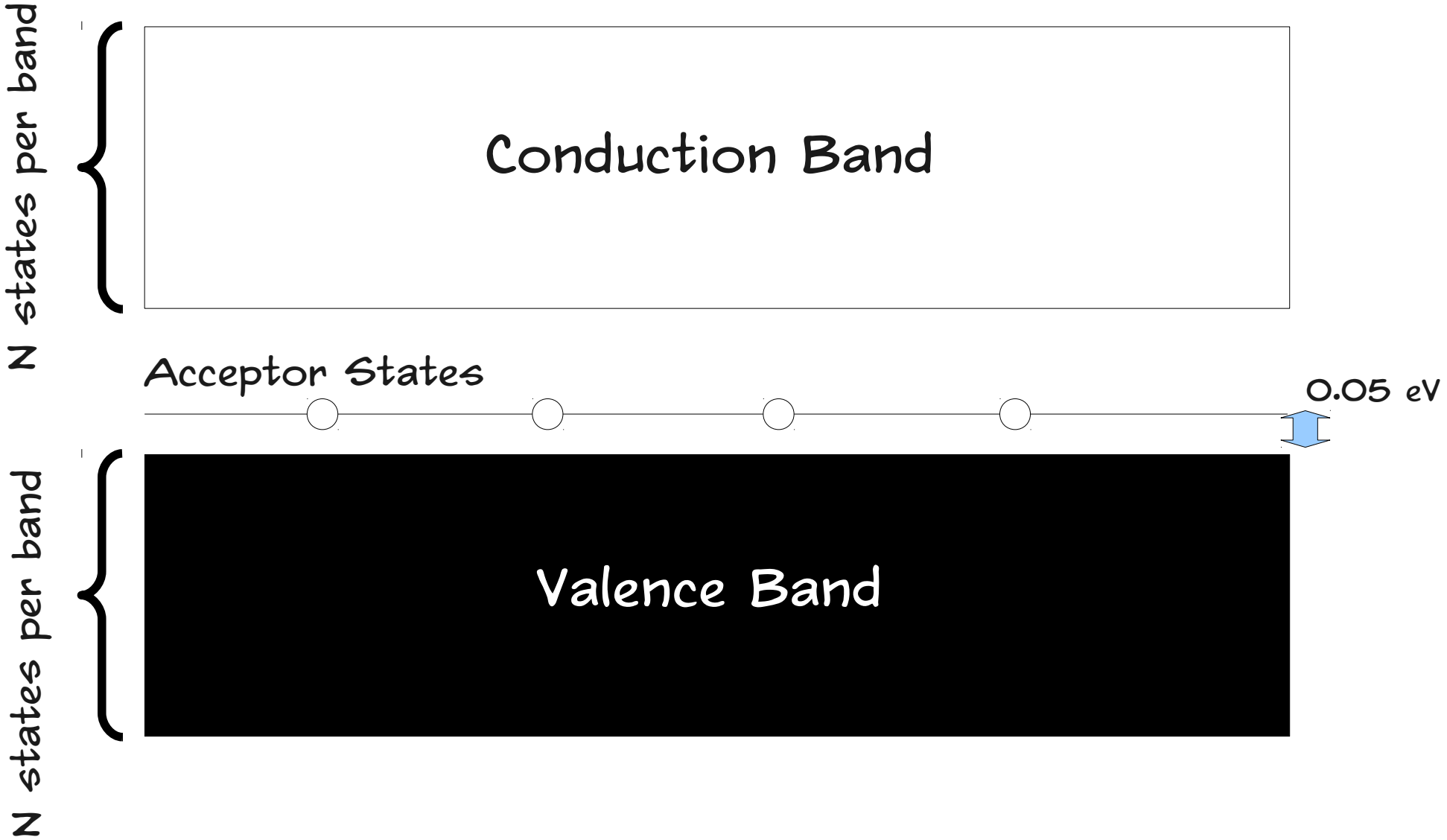
N-TYPE EXTRINSIC SEMICONDUCTOR (T=0)



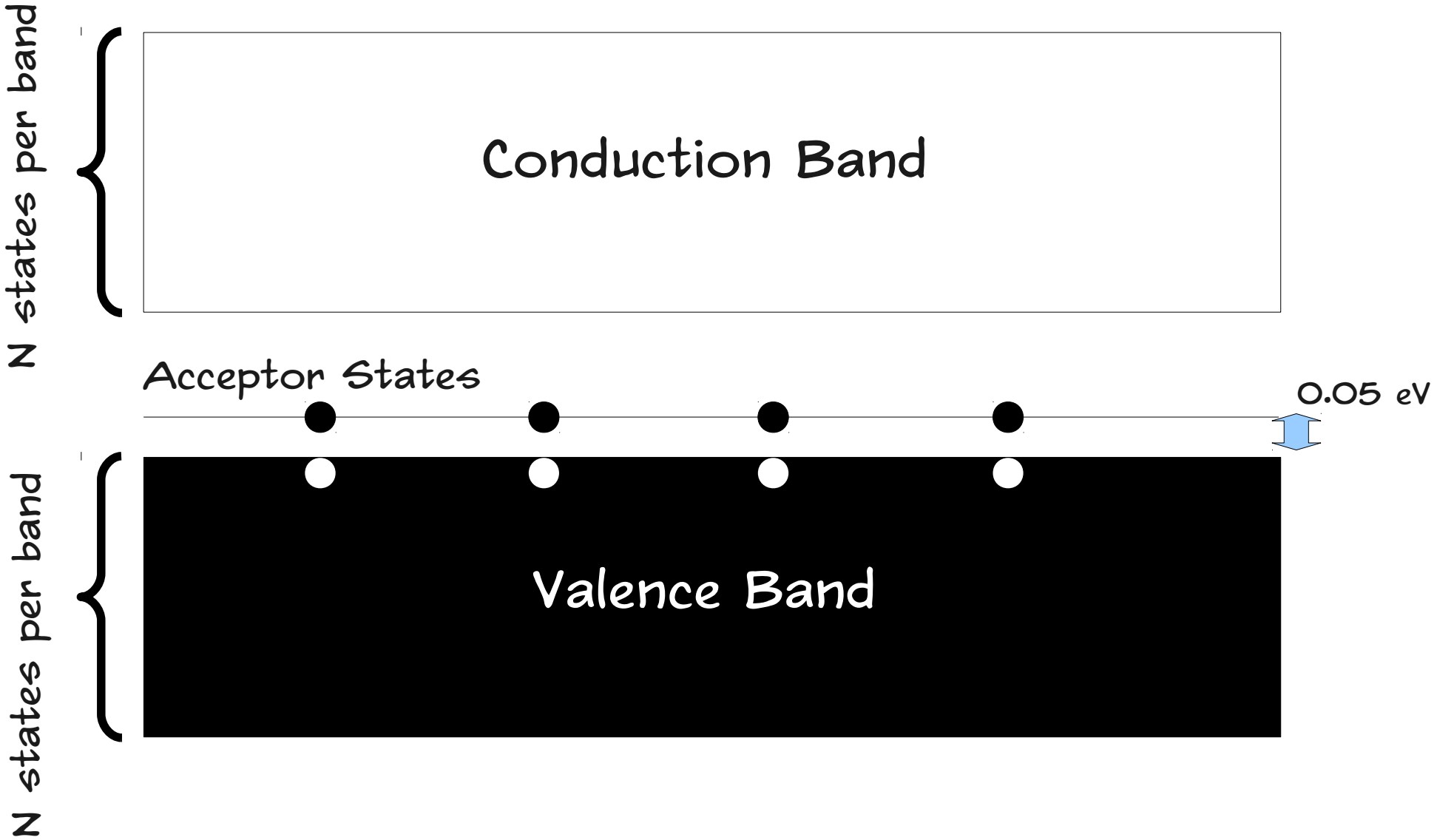
N-TYPE EXTRINSIC SEMICONDUCTOR (T>0)



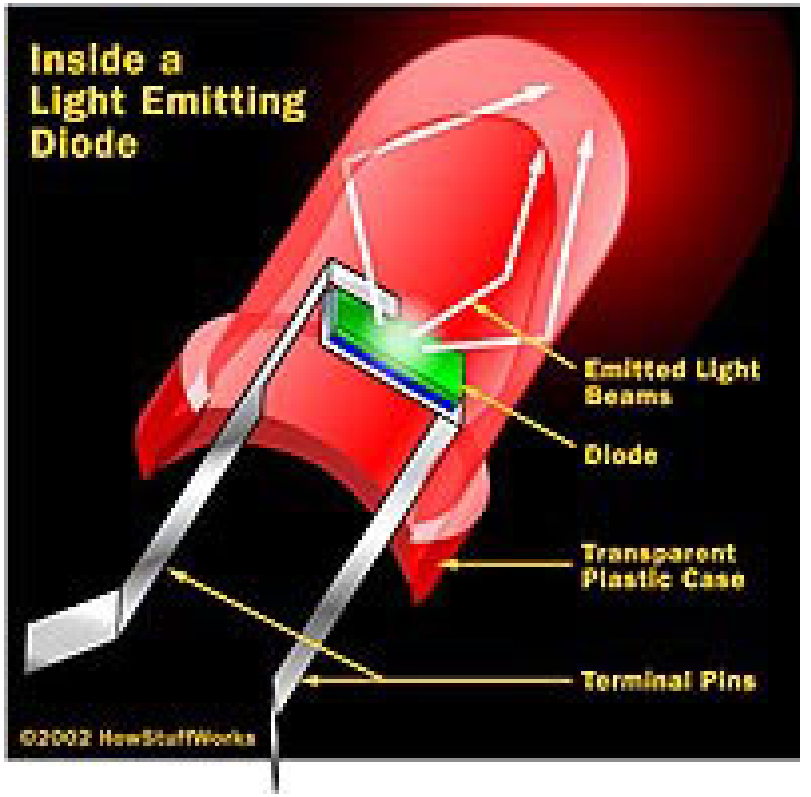
P-TYPE EXTRINSIC SEMICONDUCTOR (T=0)

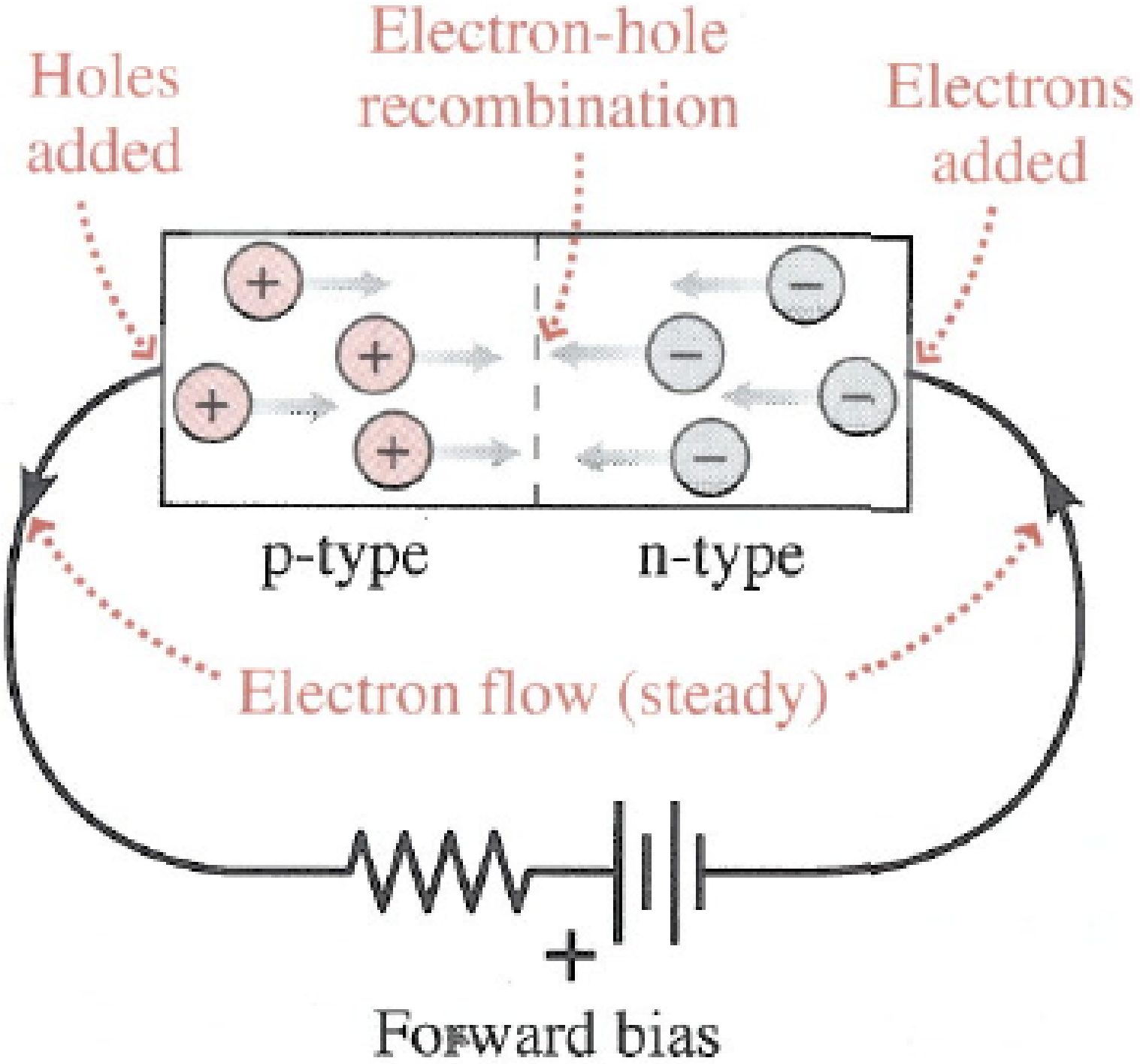


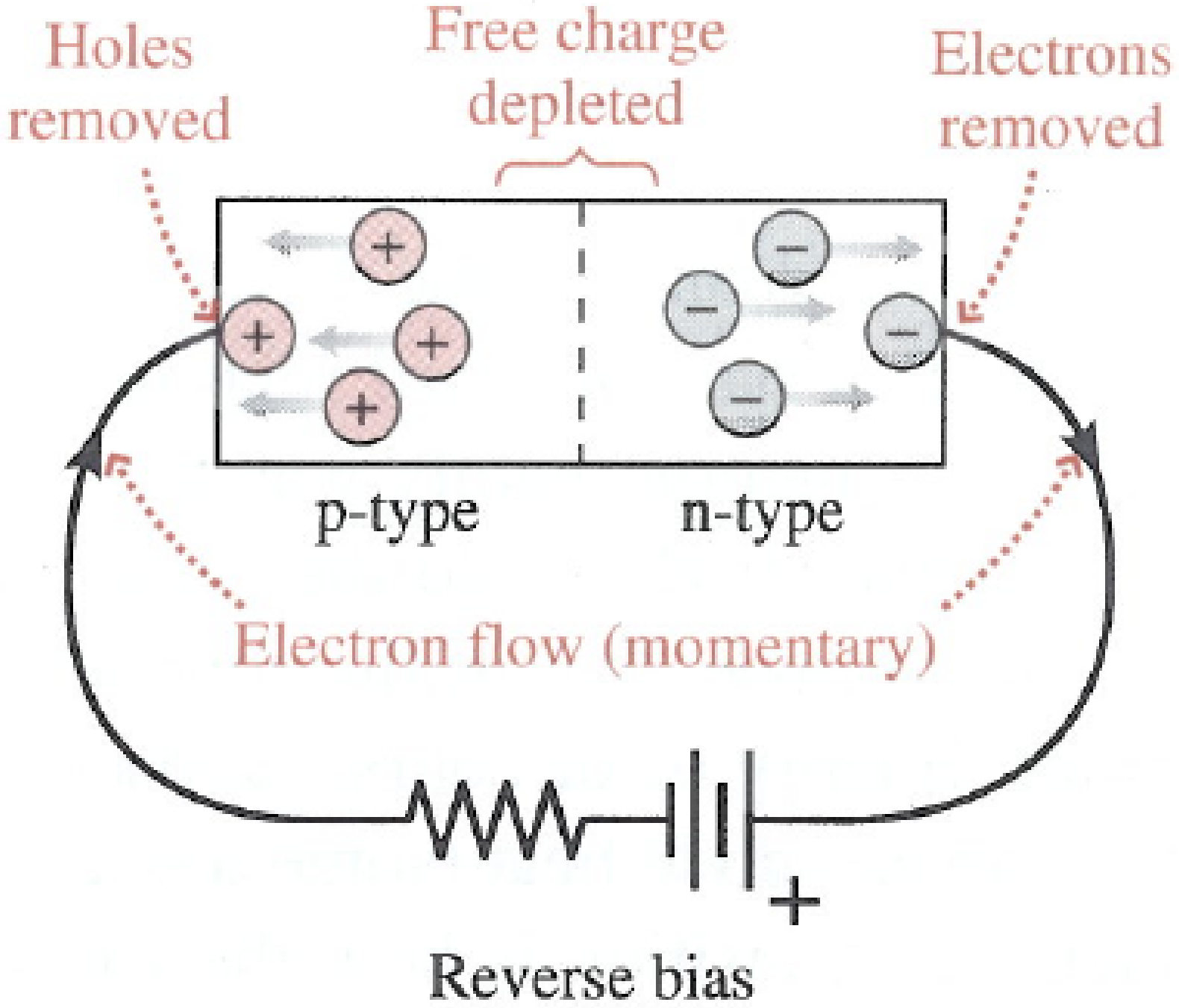
P-TYPE EXTRINSIC SEMICONDUCTOR (T>0)



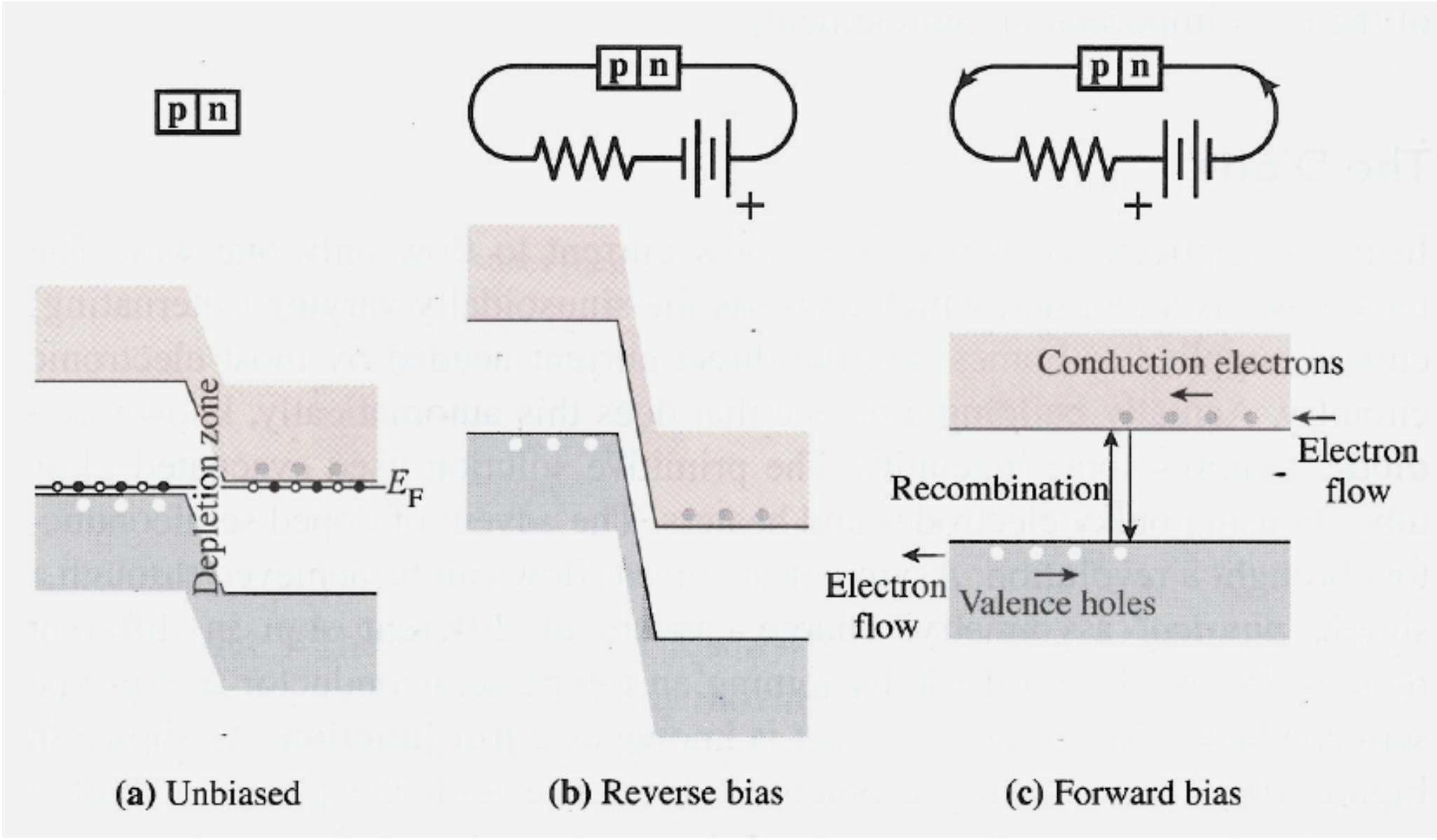
THE DIODE


Inside a
Light Emitting
Diode
Emitted Light
Beams
Diode
Transparent
Plastic Case
Terminal Pins
©2002 HowStuffWorks

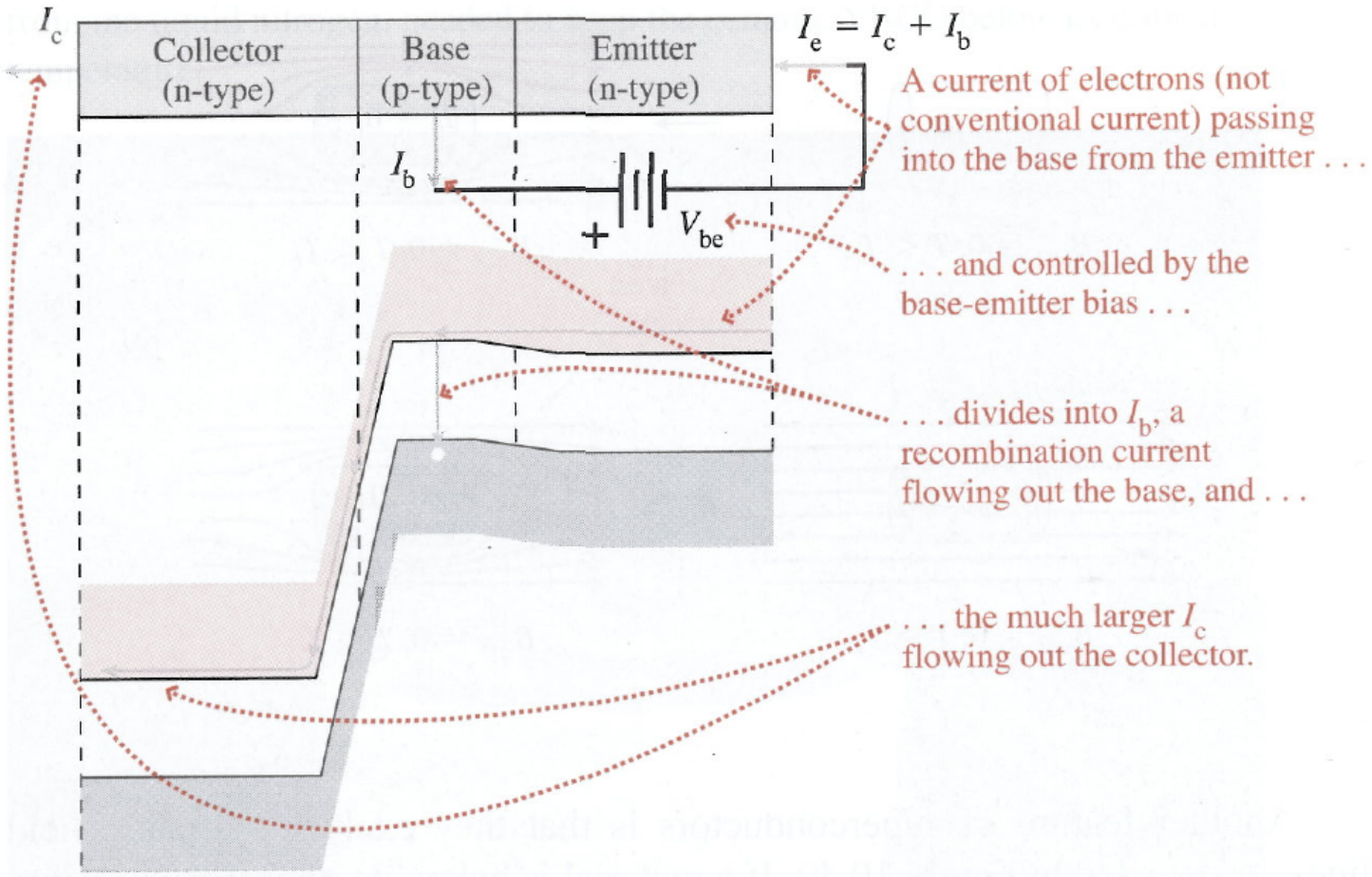

Holes added
Electron-hole recombination
Electrons added
p-type
n-type
Electron flow (steady)
+
Forward bias

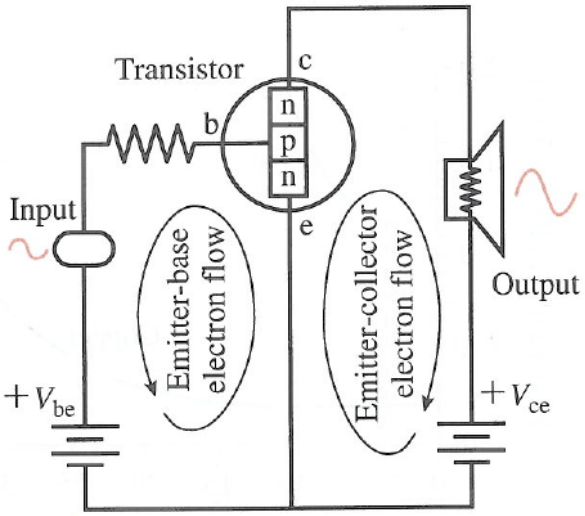

Holes
removed
Free charge
depleted
Electrons
removed
p-type
n-type
Electron flow (momentary)
+
Reverse bias

ENERGY BAND PICTURE



TRANSISTOR


I_c
Collector (n-type)
Base (p-type)
Emitter (n-type)
$I_e = I_c + I_b$
I_b
V_{be}
+
A current of electrons (not conventional current) passing into the base from the emitter . . .
. . . and controlled by the base-emitter bias . . .
. . . divides into I_b, a recombination current flowing out the base, and . . .
. . . the much larger I_c flowing out the collector.


Transistor
c
b
n
p
n
e
Input
Output
Emitter-base electron flow
Emitter-collector electron flow
$+V_{be}$
$+V_{ce}$

NEXT TIME

- Superconductivity
- Nuclear Physics
- Good presentation style
- Reading for next time: Harris Ch. 10.9, 11.1-11.2