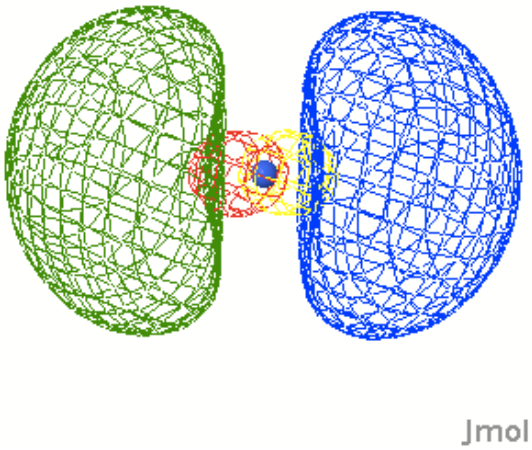
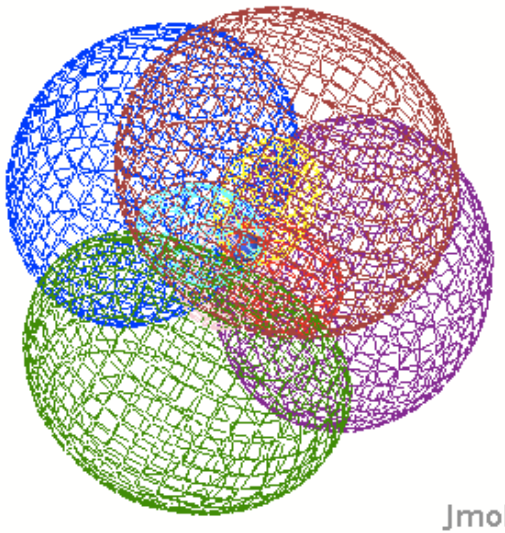
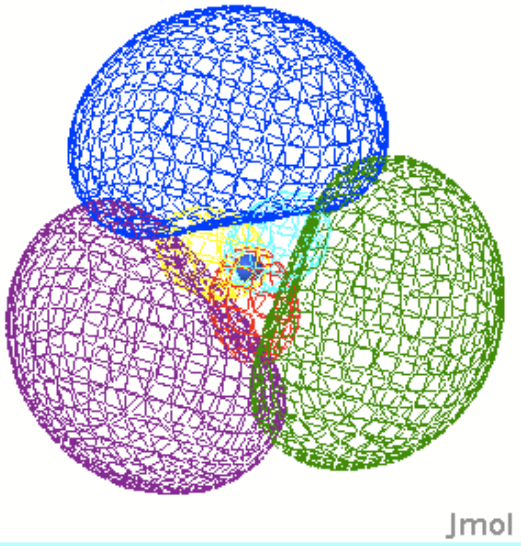
Which represents sp^3 orbitals?



(1)



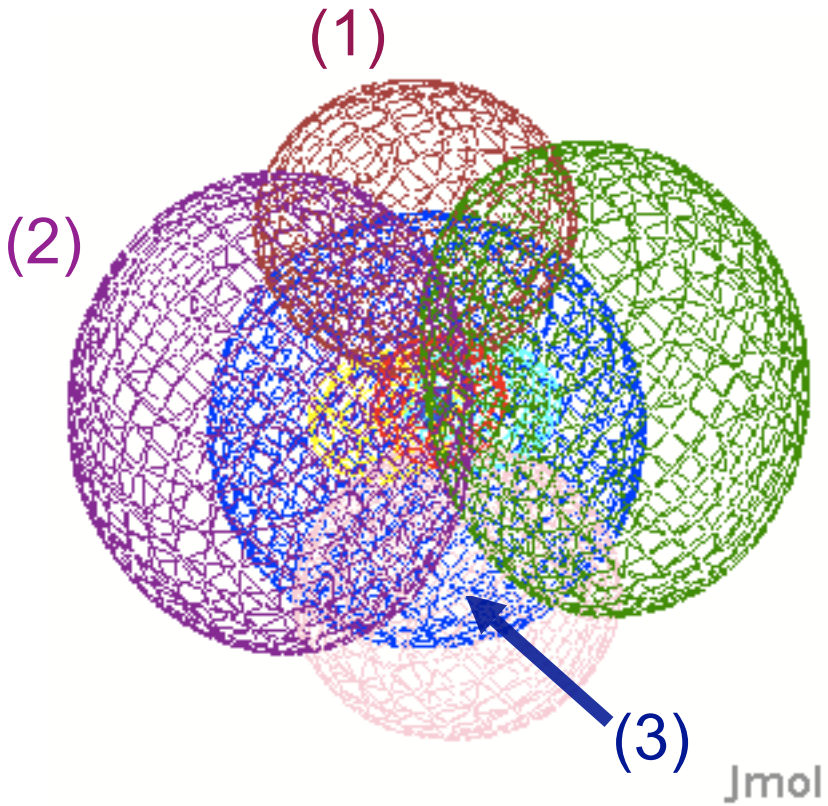
(2)

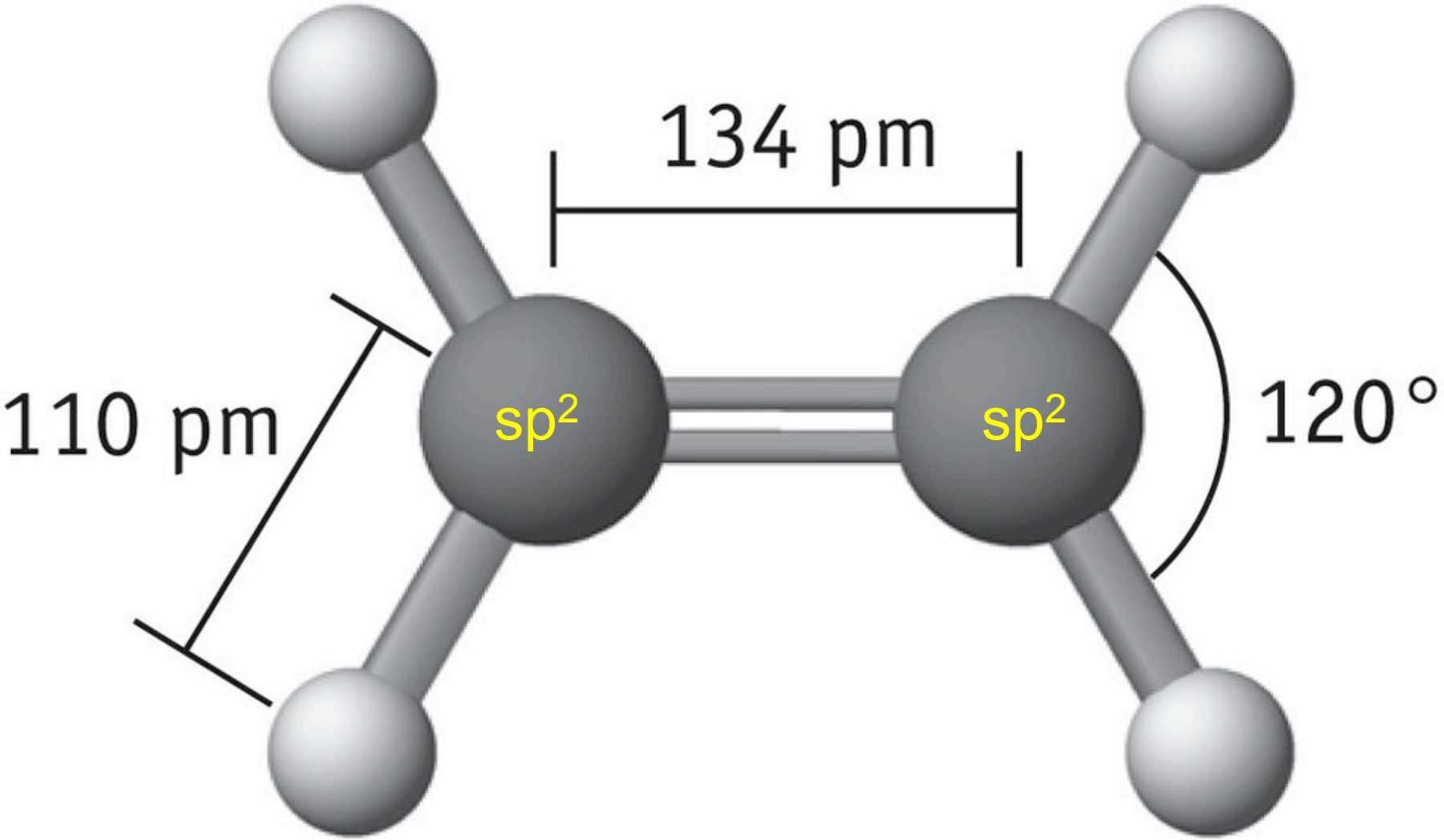


(3)

sp^2 hybridization

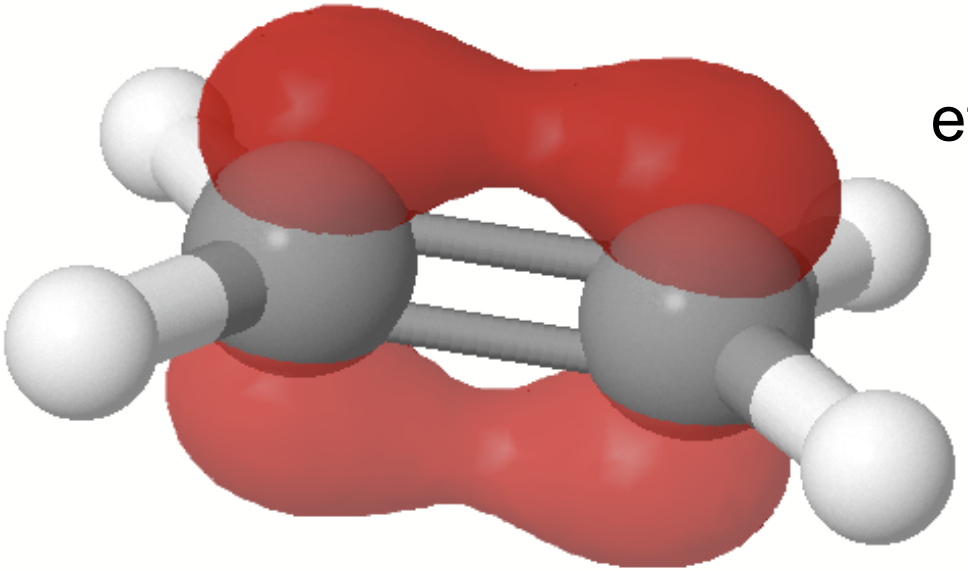
Which is the unused p orbital?





Ethylene, C_2H_4

What is shown in red?

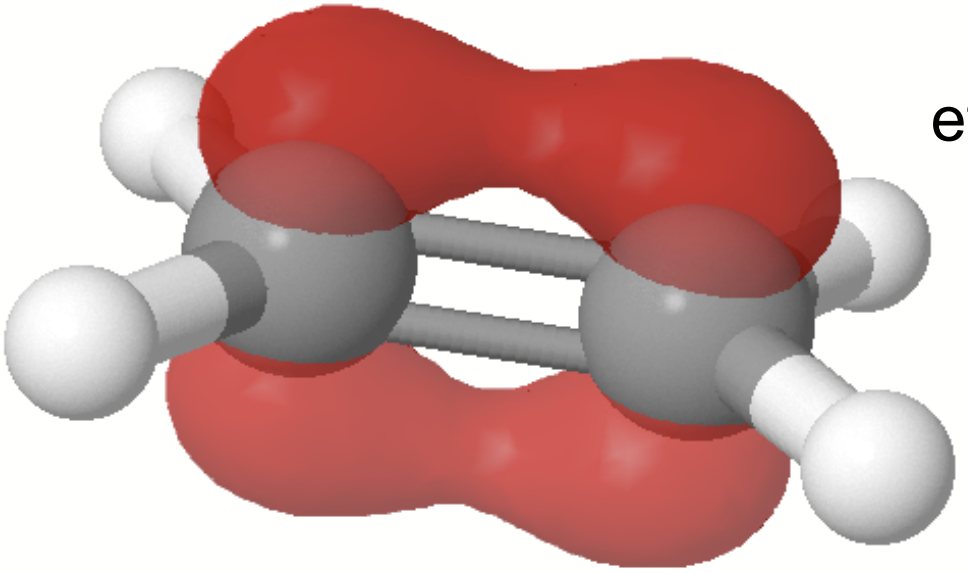


ethylene

1) Two π bonding orbitals
2) One π bonding and one p antibonding orbital
3) One π bonding orbital
4) One π antibonding orbital
5) Two p orbitals

See in 3D!

What is shown in red?

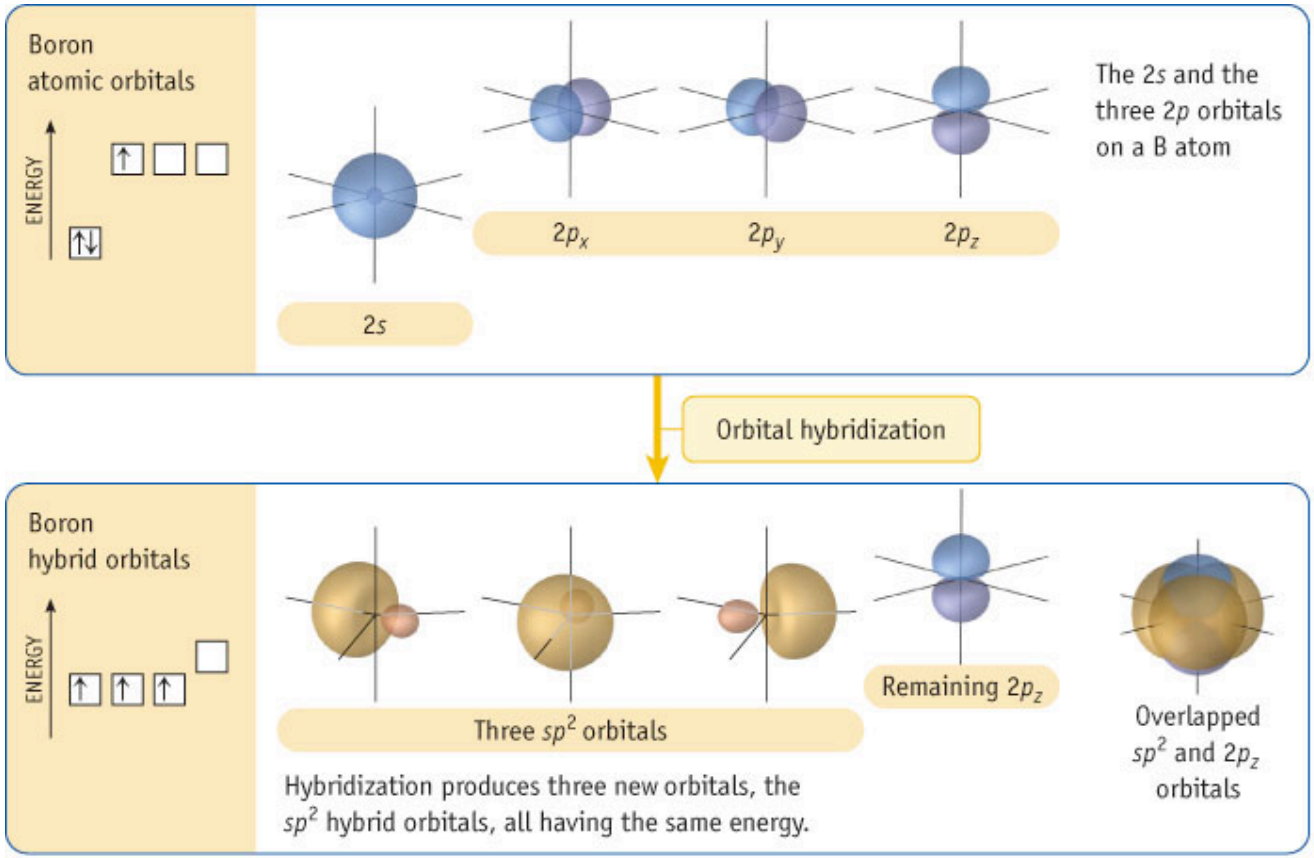


ethylene

1) Two π bonding orbitals
2) One π bonding and one p antibonding orbital
3) **One π bonding orbital**
4) One π antibonding orbital
5) Two p orbitals

sp^2 hybridization

View in 3D!



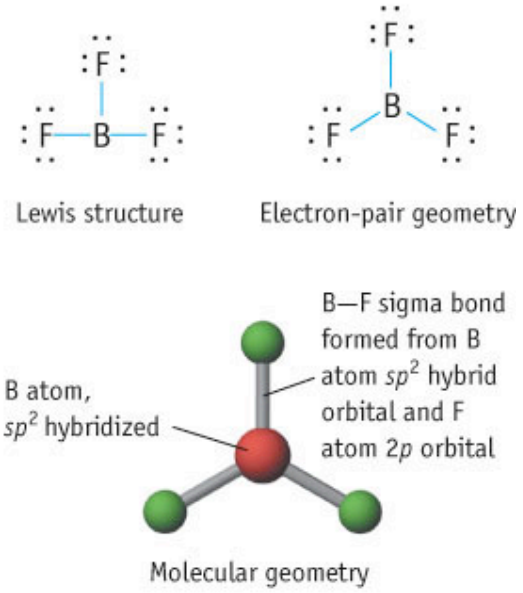
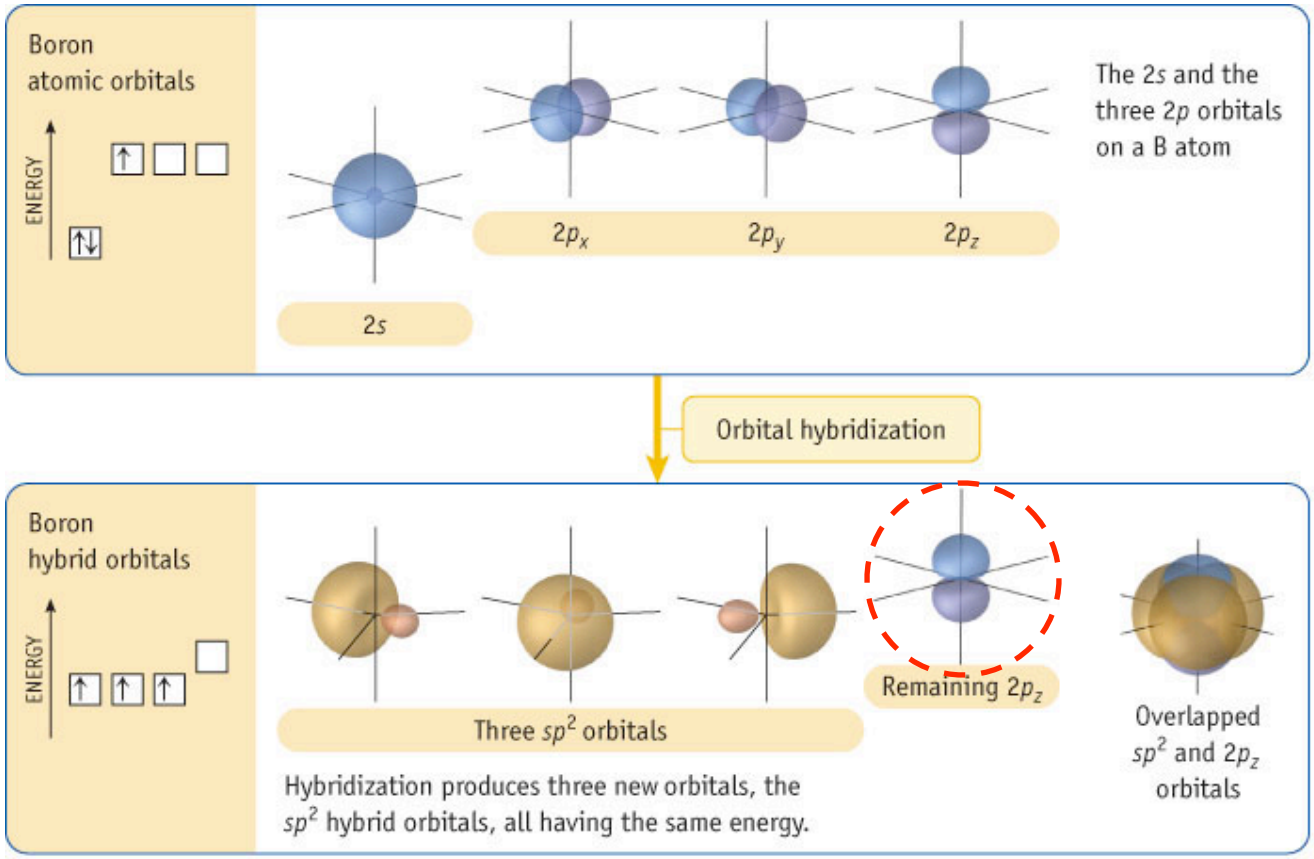
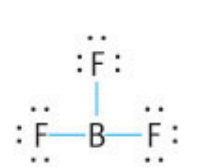


Fig. 9-8, p. 414

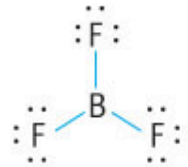
sp^2 hybridization

View in 3D!

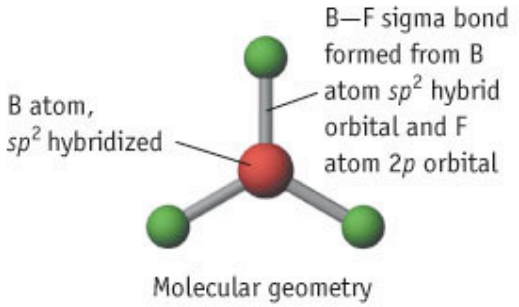




Lewis structure



Electron-pair geometry



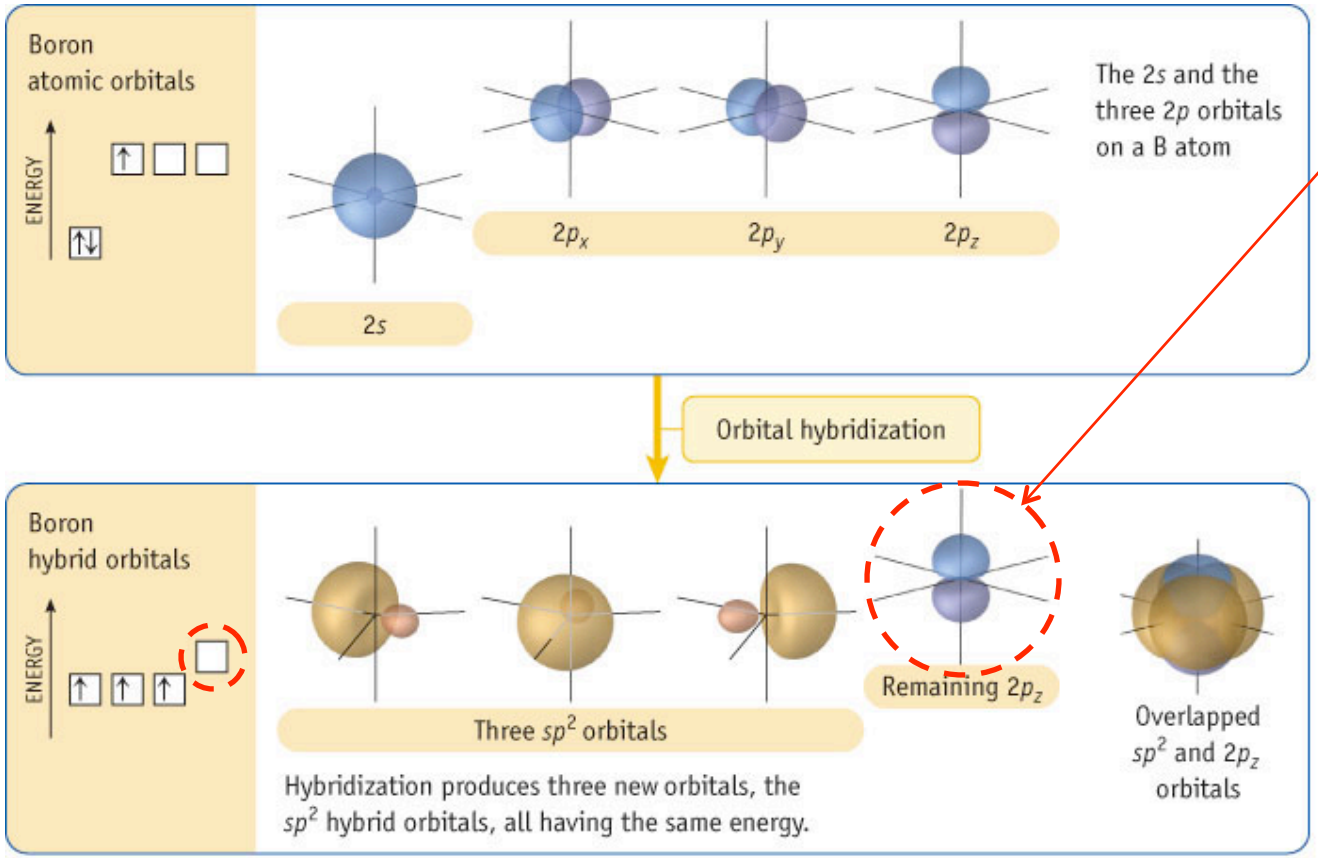
Molecular geometry

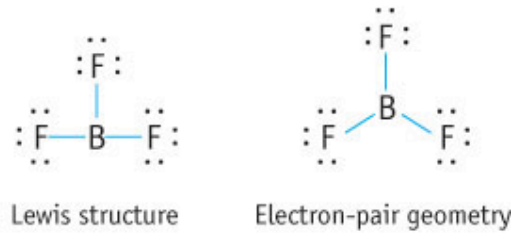
Fig. 9-8, p. 414

sp^2 hybridization

View in 3D!

Left over (unused) atomic orbital





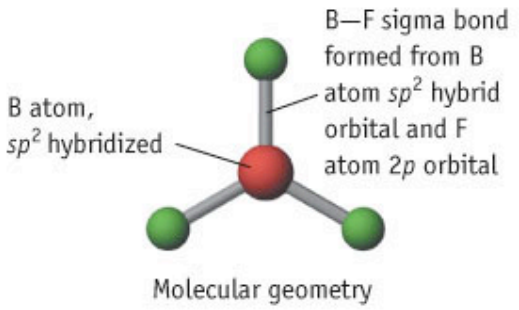
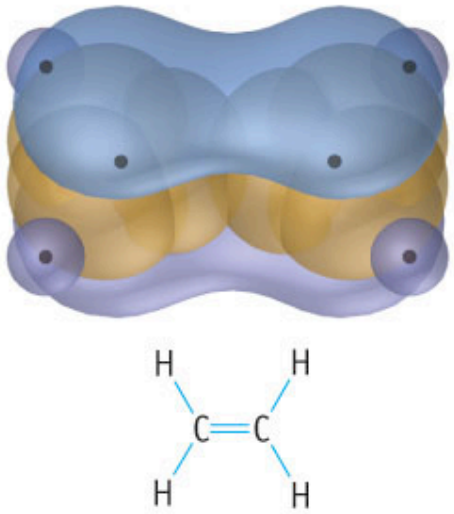


Fig. 9-8, p. 414

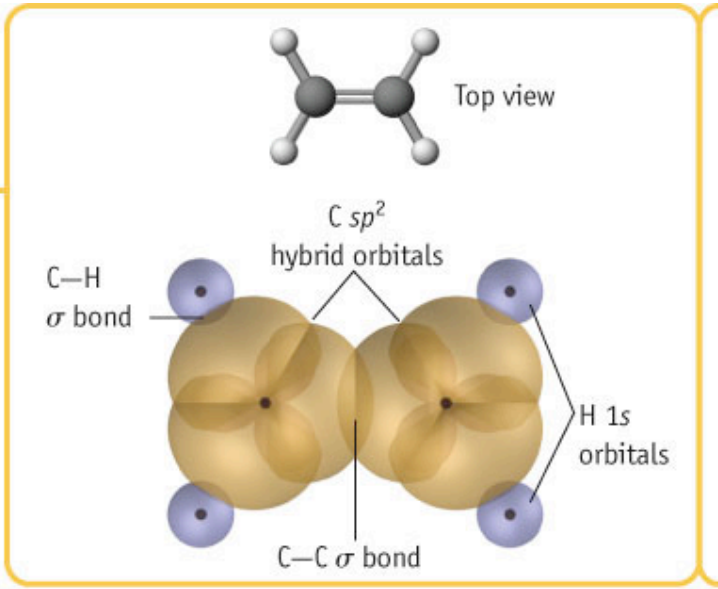
Unhybridized *p* orbital. Used for π bonding in C_2H_4.

Three sp^2 hybrid orbitals. Used for C—H and C—C σ bonding in C_2H_4.

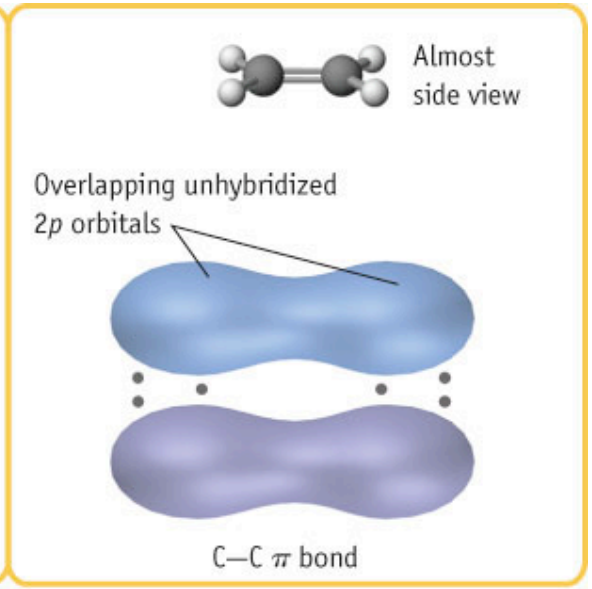
See in 3D!



(a) Lewis structure and bonding of ethylene, C_2H_4.



(b) The C—H σ bonds are formed by overlap of C atom sp^2 hybrid orbitals with H atom 1s orbitals. The σ bond between C atoms arises from overlap of sp^2 orbitals.

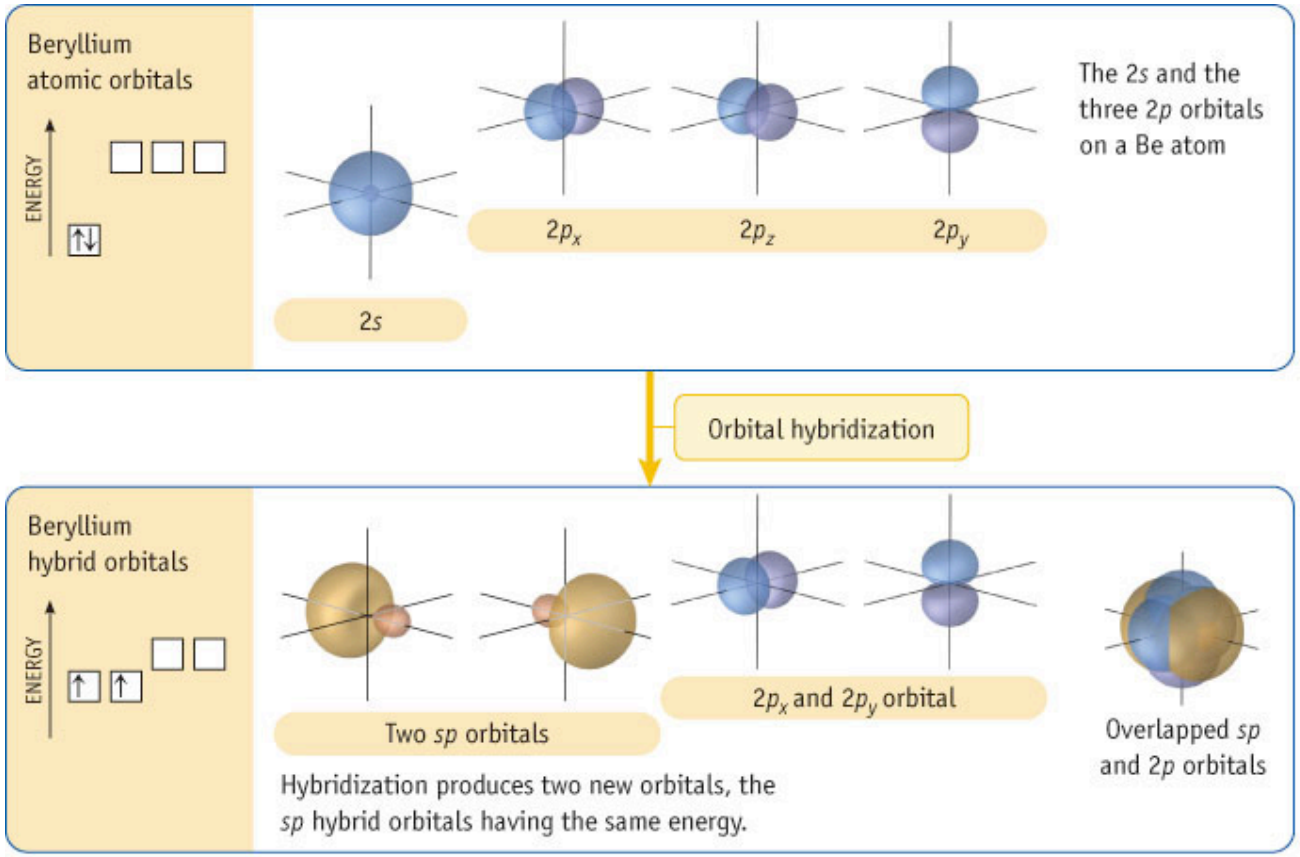


(c) The carbon–carbon π bond is formed by overlap of an unhybridized 2p orbital on each atom. Note the lack of electron density along the C—C bond axis from this bond.

Fig. 9-10, p. 417

sp hybridization

See in 3D!



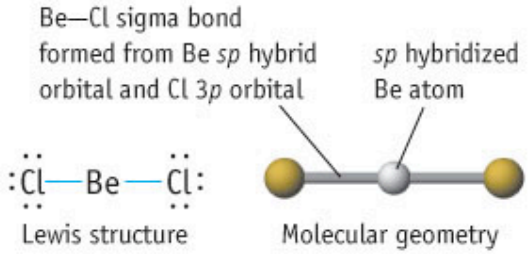
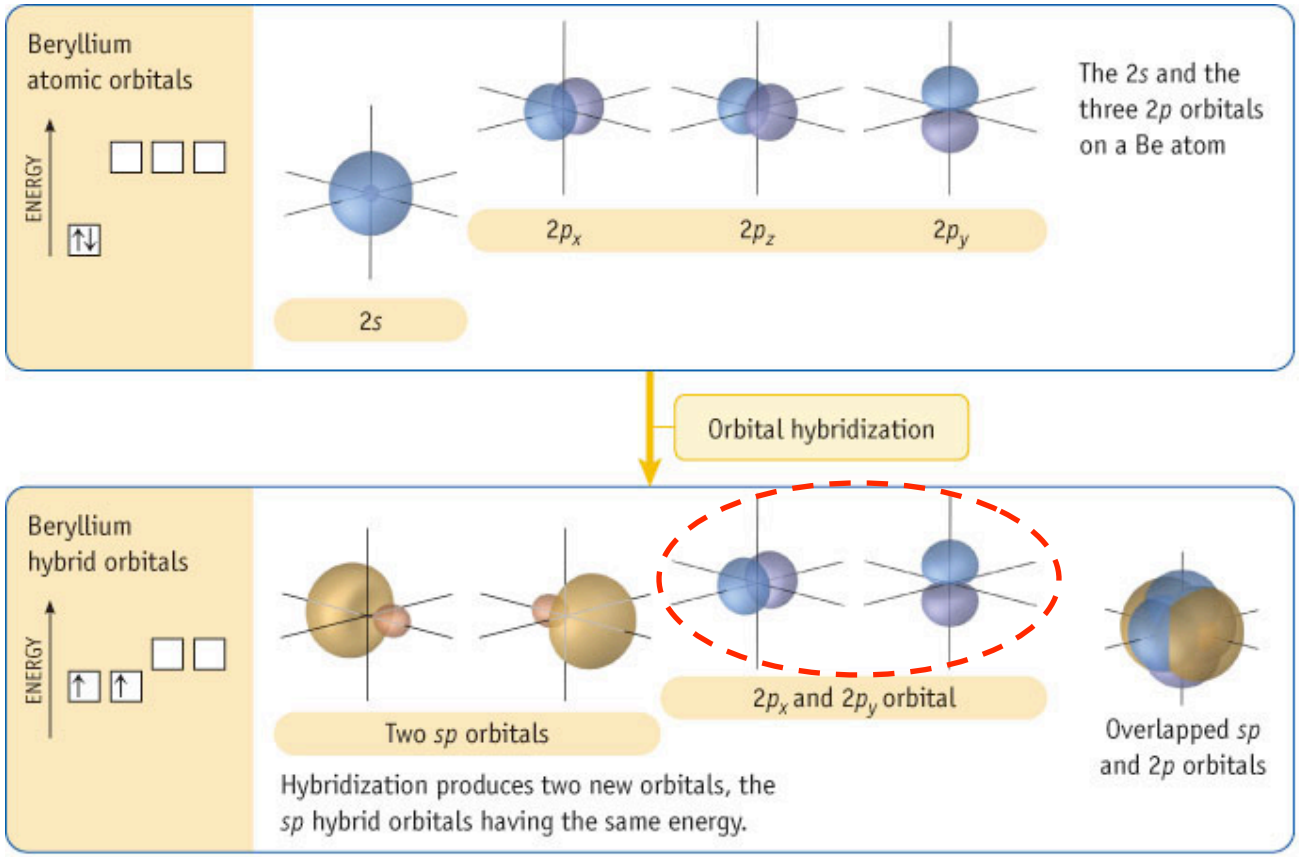


Fig. 9-9, p. 415

sp hybridization

See in 3D!



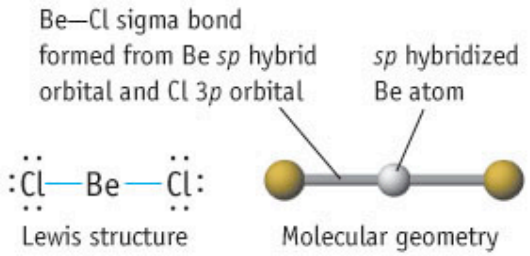
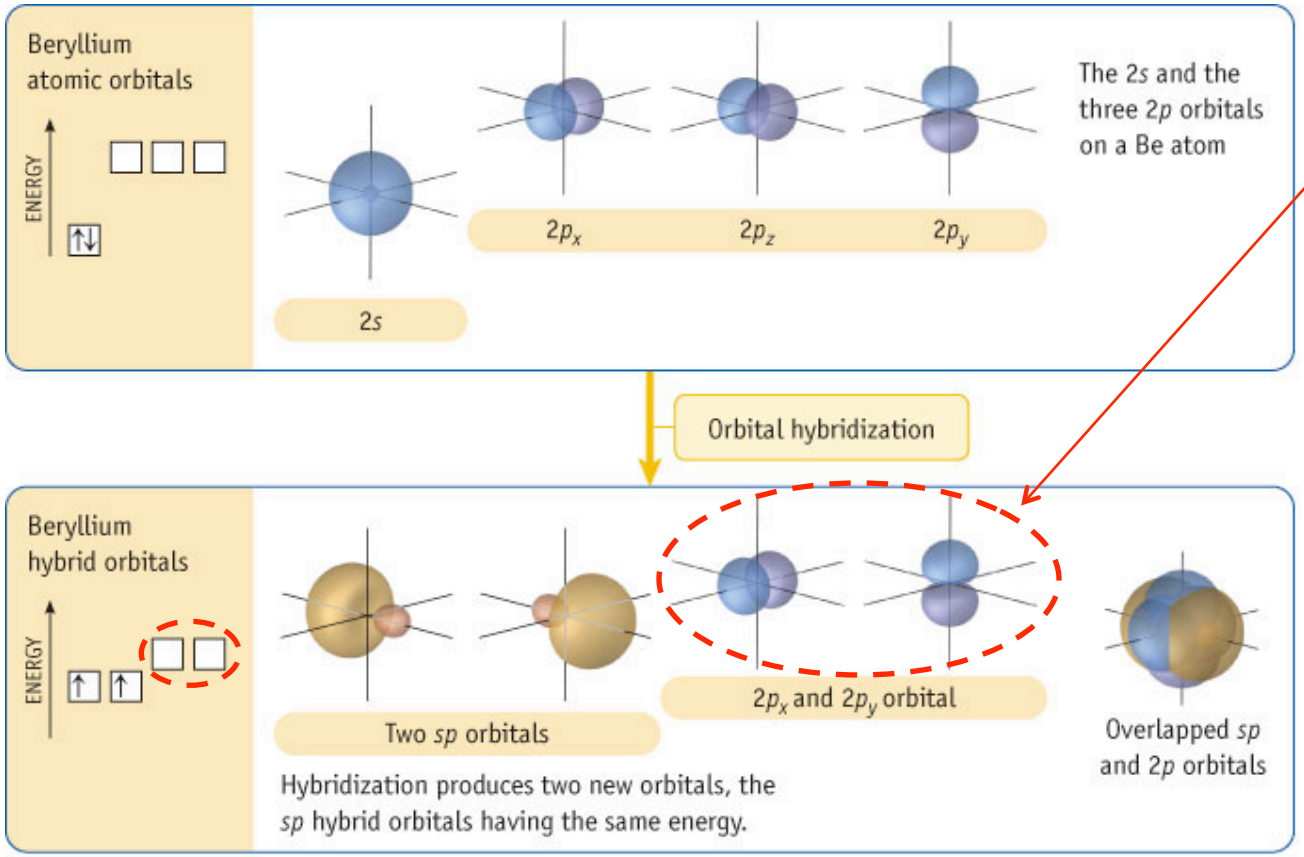


Fig. 9-9, p. 415

sp hybridization

See in 3D!

Left over (unused) atomic orbitals



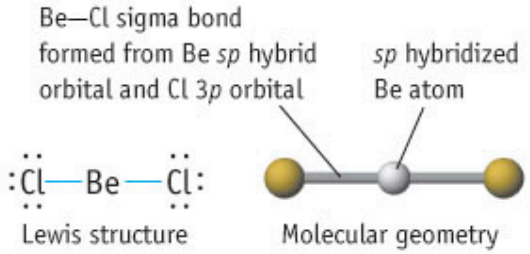


Fig. 9-9, p. 415

See in 3D!

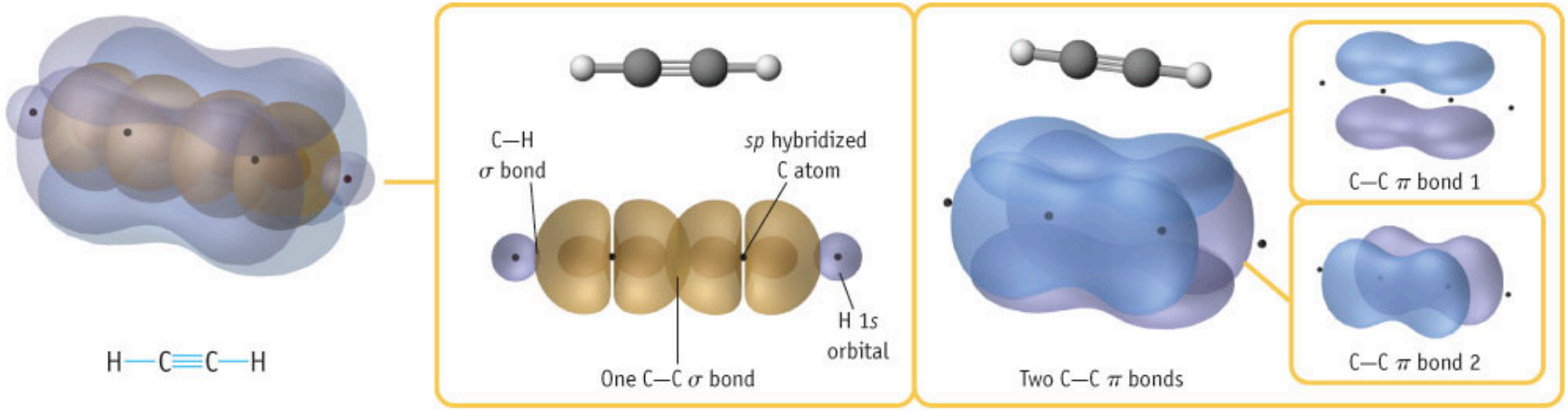
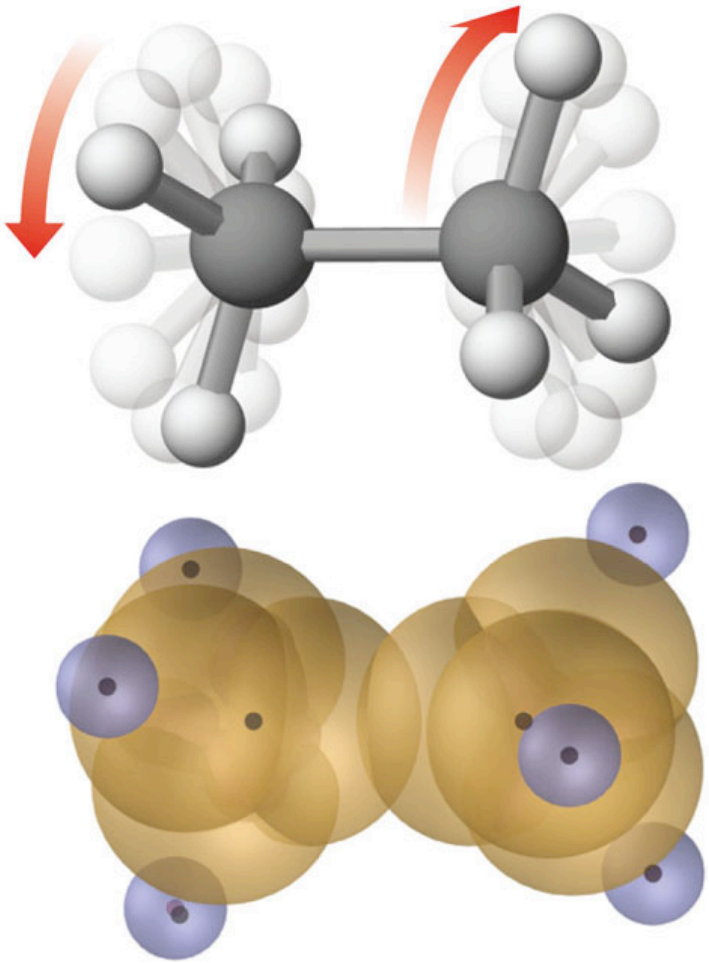


Fig. 9-12, p. 419

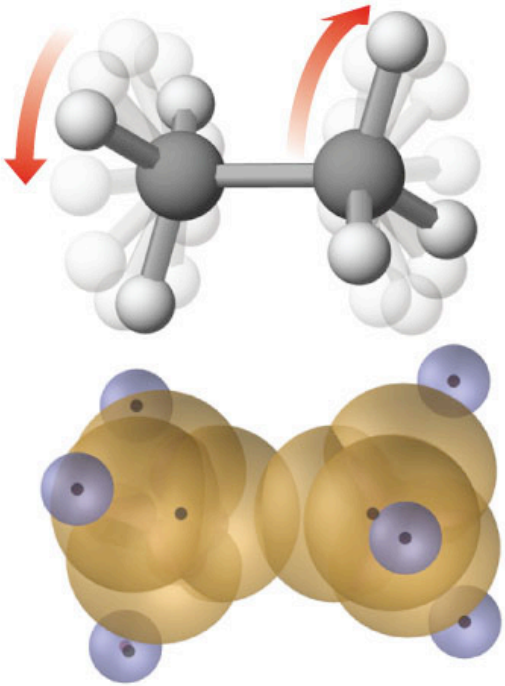
Free Rotation



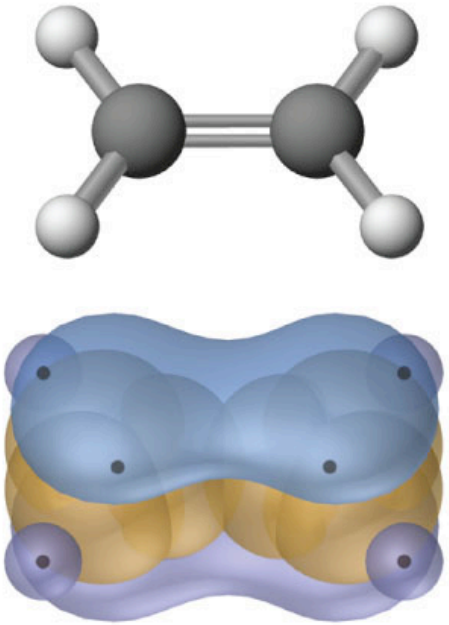
(a) In ethane nearly free rotation can occur around the axis of a single (σ) bond.

Restricted Rotation

Formation of pi bonds requires good overlap



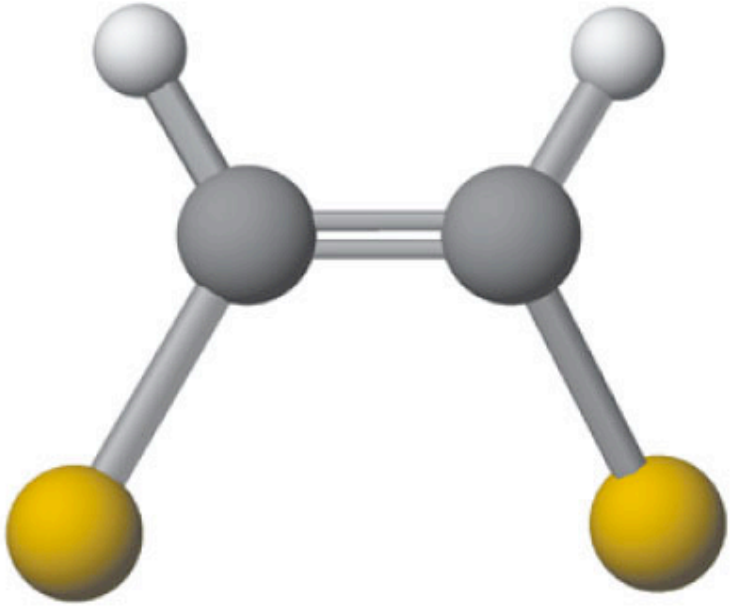
(a) In ethane nearly free rotation can occur around the axis of a single (σ) bond.



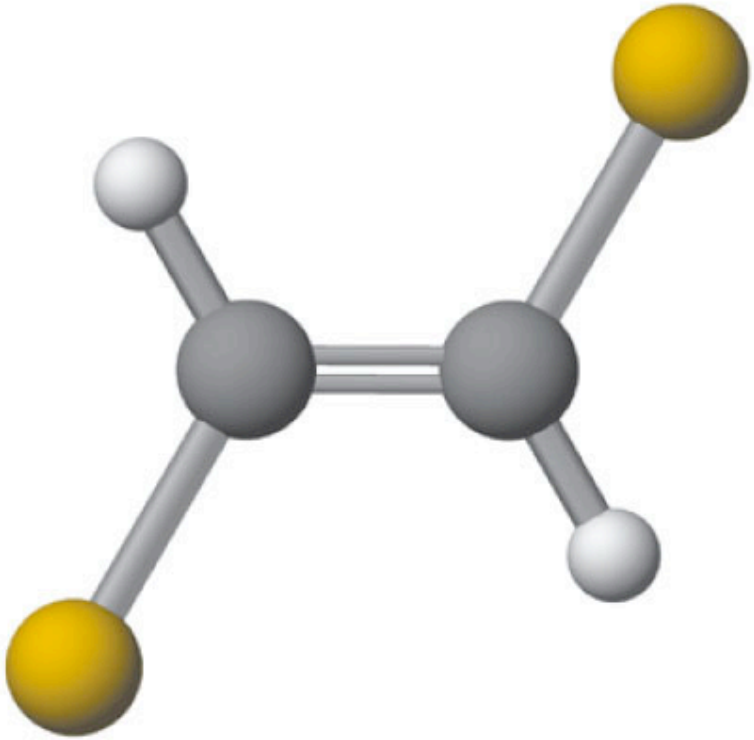
(b) Ethylene rotation is severely restricted around double bonds because doing so would break the π bond, a process generally requiring a great deal of energy.

Restricted Rotation

cis-trans isomers do not interconvert readily



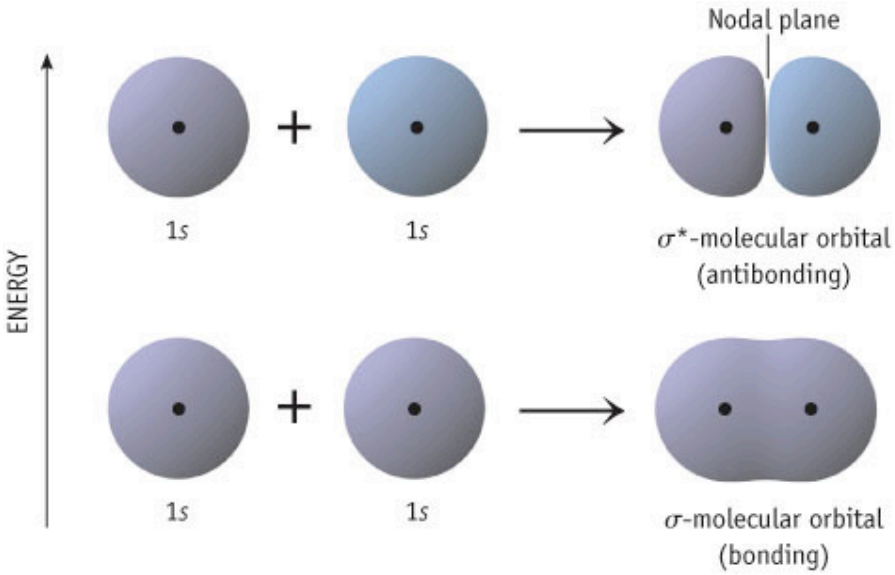
cis-1,2-dichloroethylene



trans-1,2-dichloroethylene

Back to H_2

Conserve energy when “mixing” orbitals



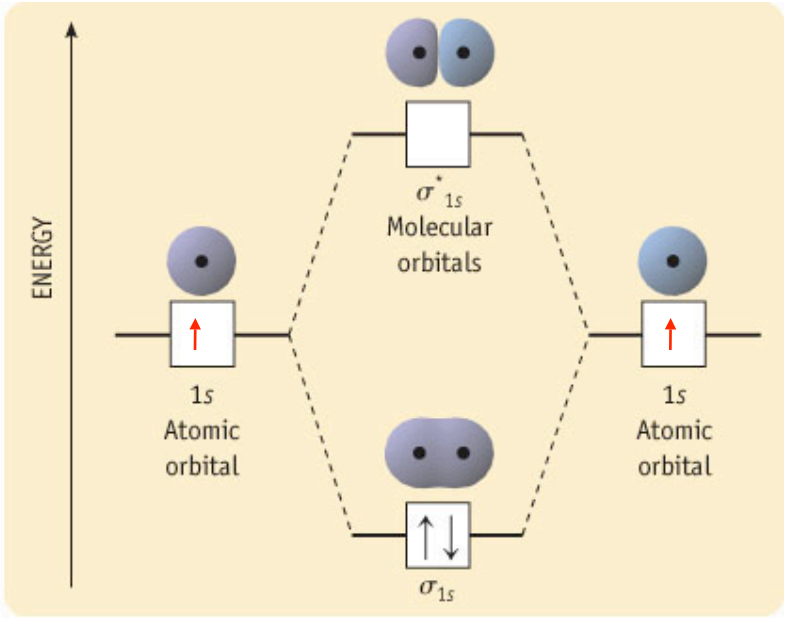


Fig. 9-16, p. 424

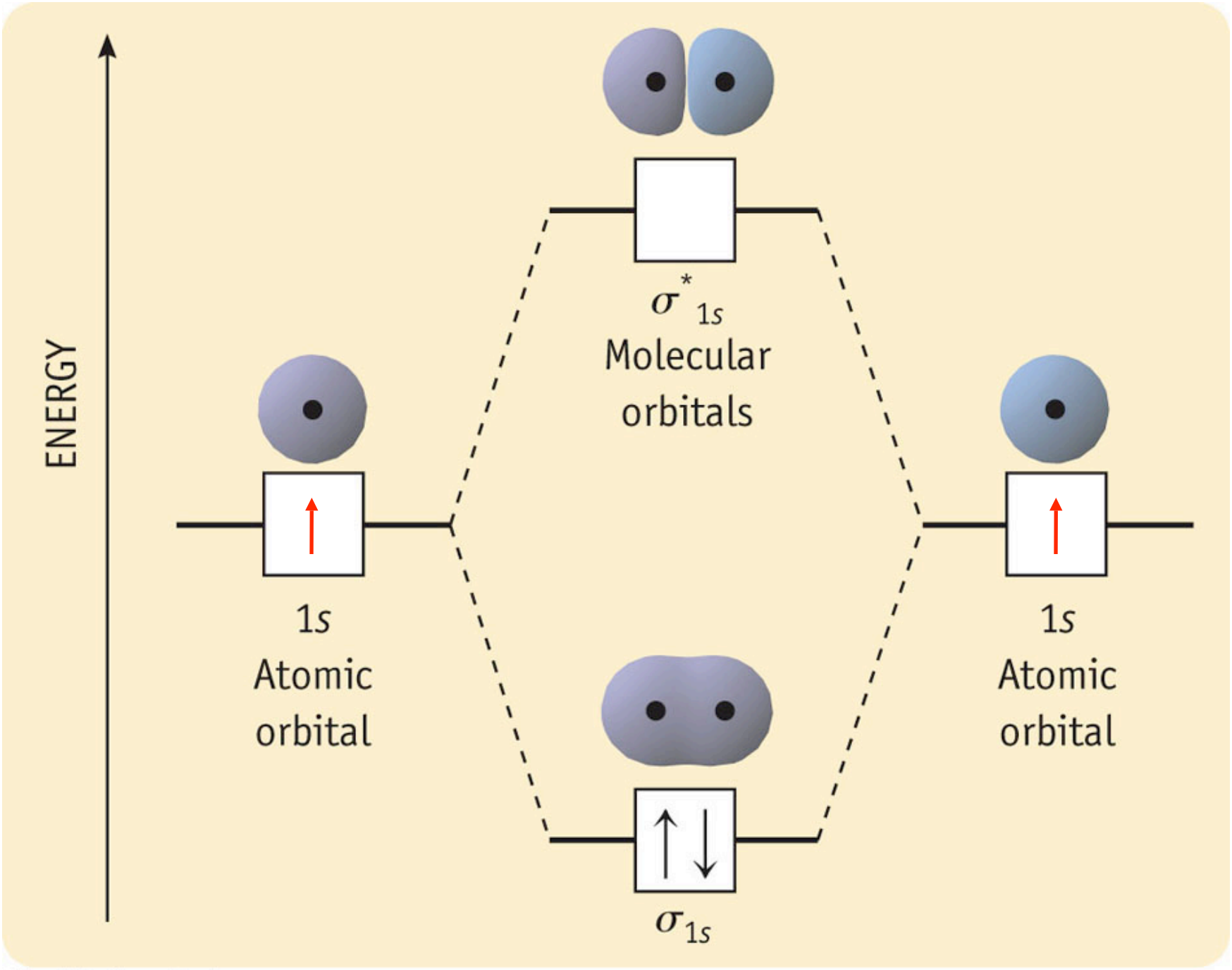


Fig. 9-16, p. 424

He_2

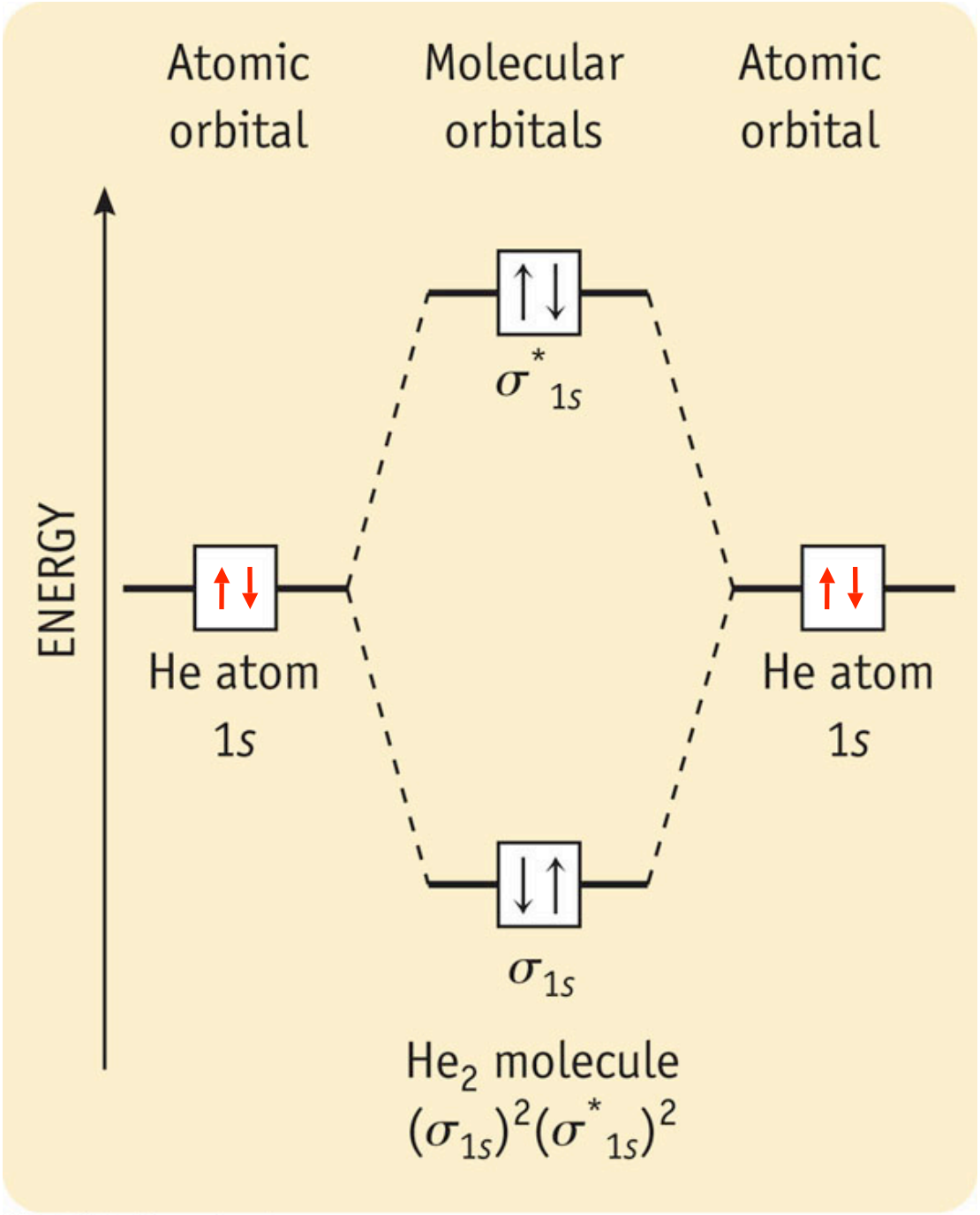


Fig. 9-17, p. 424

He_2

Doesn't exist

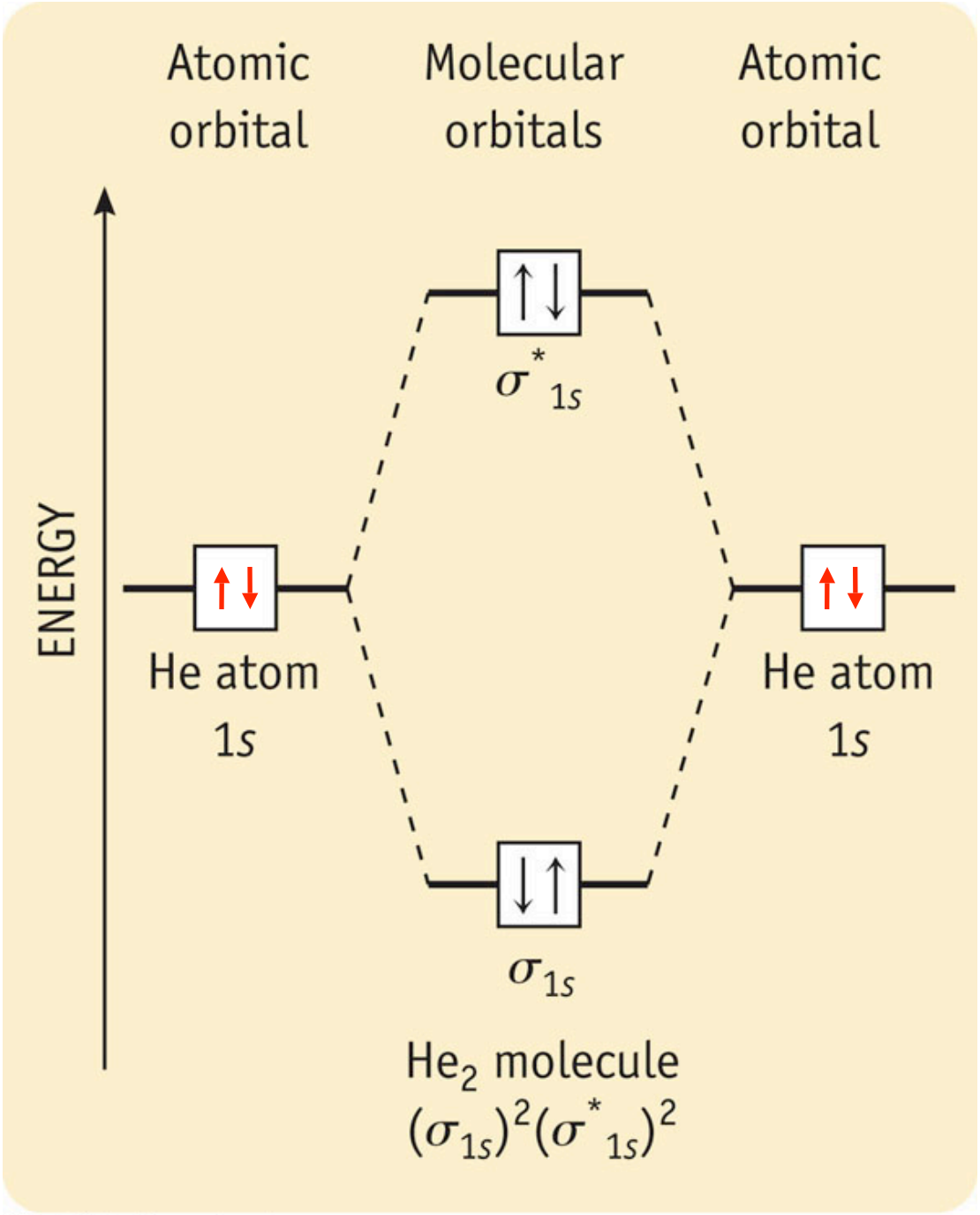


Fig. 9-17, p. 424

Li_2

Li - $1s^2 2s^1$

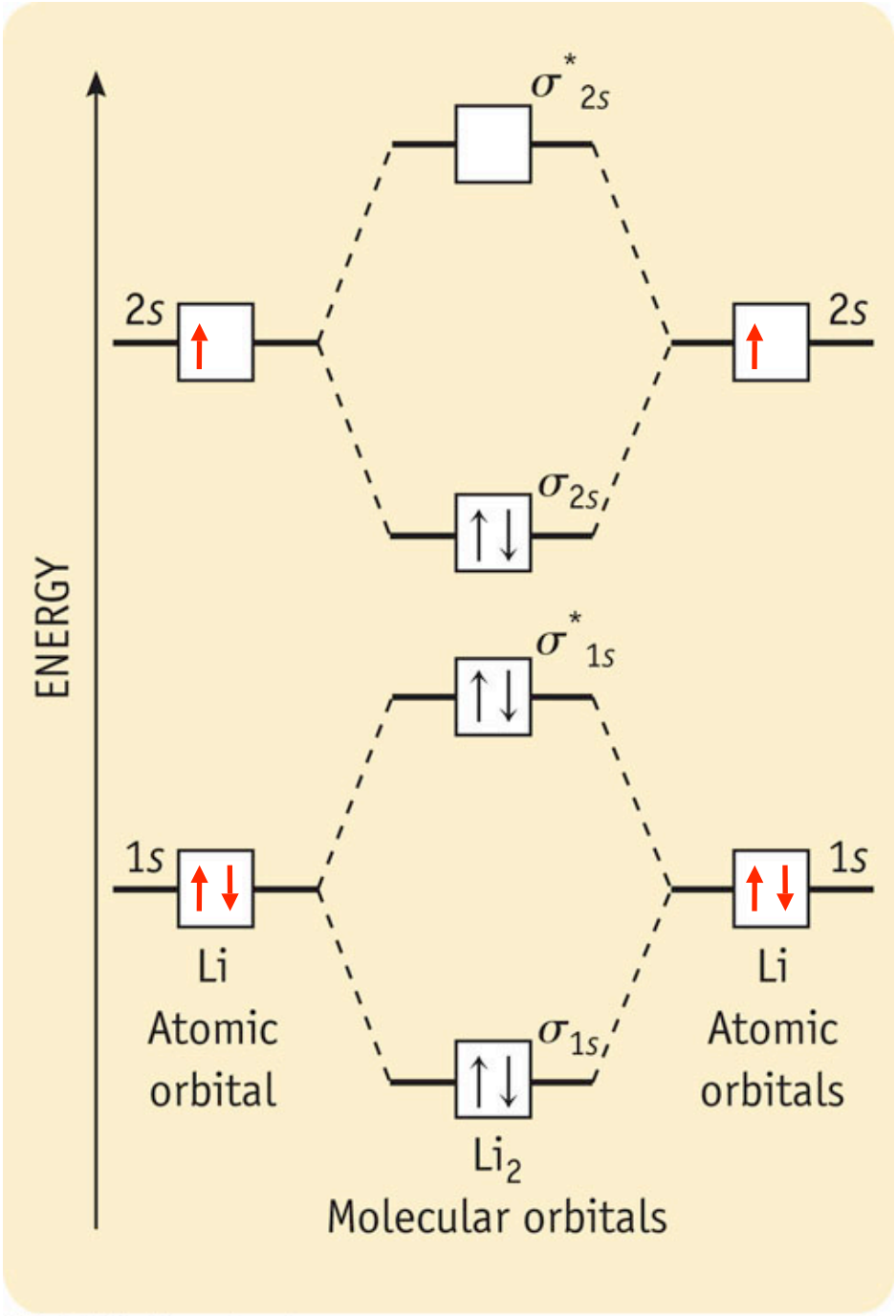


Fig. 9-18, p. 425

Li_2

Does exist

Li - $1s^2 2s^1$

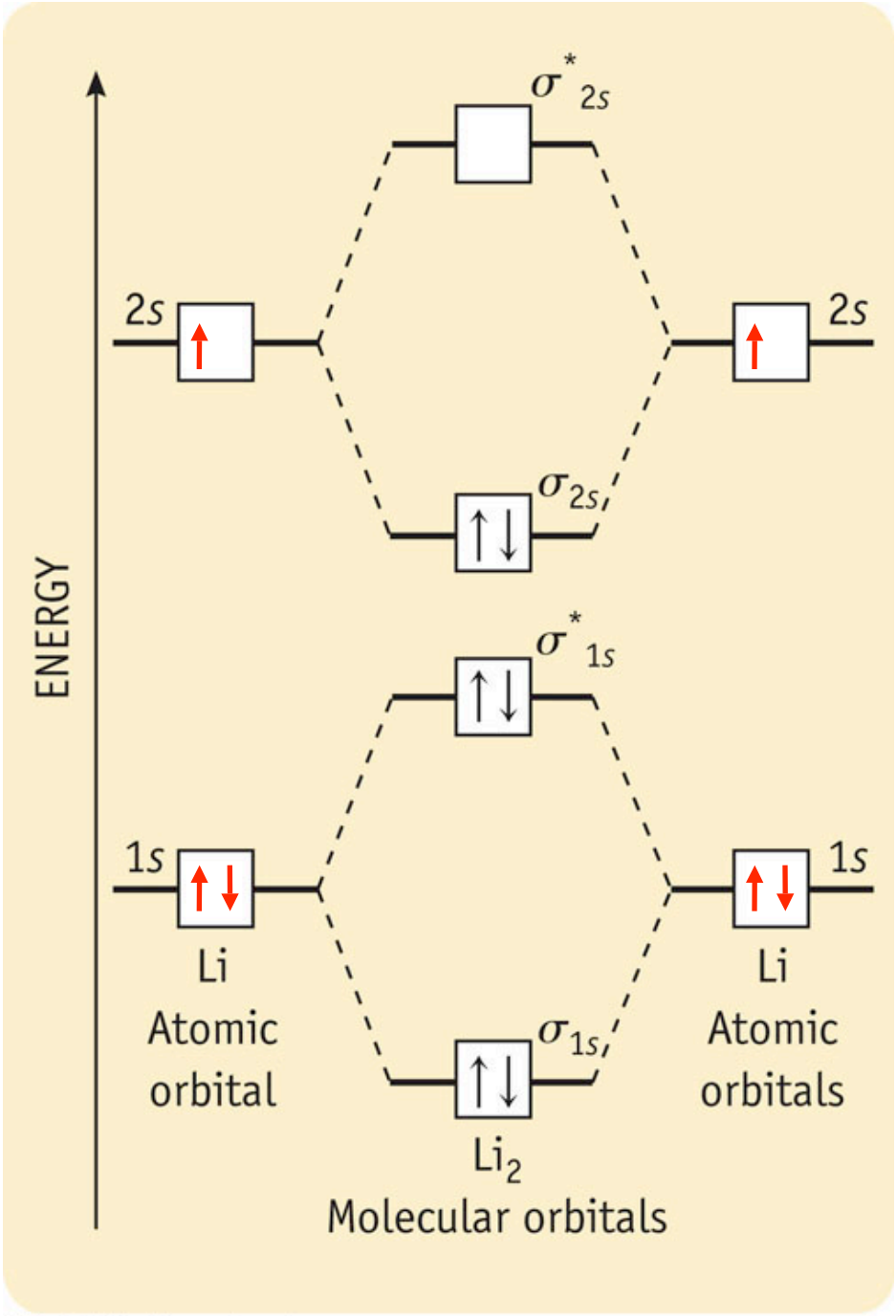


Fig. 9-18, p. 425

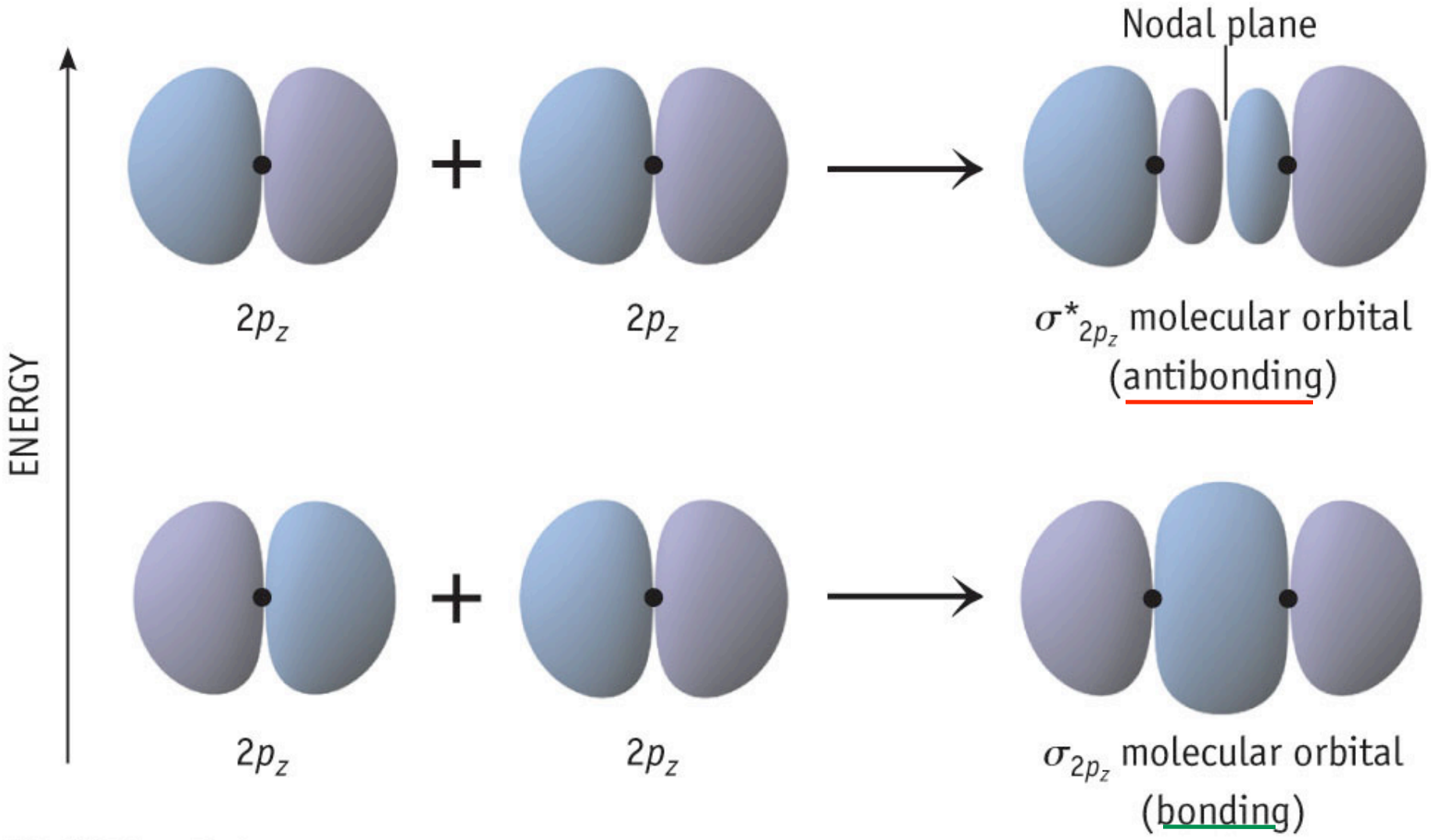


Fig. 9-19, p. 426

Atomic Orbitals

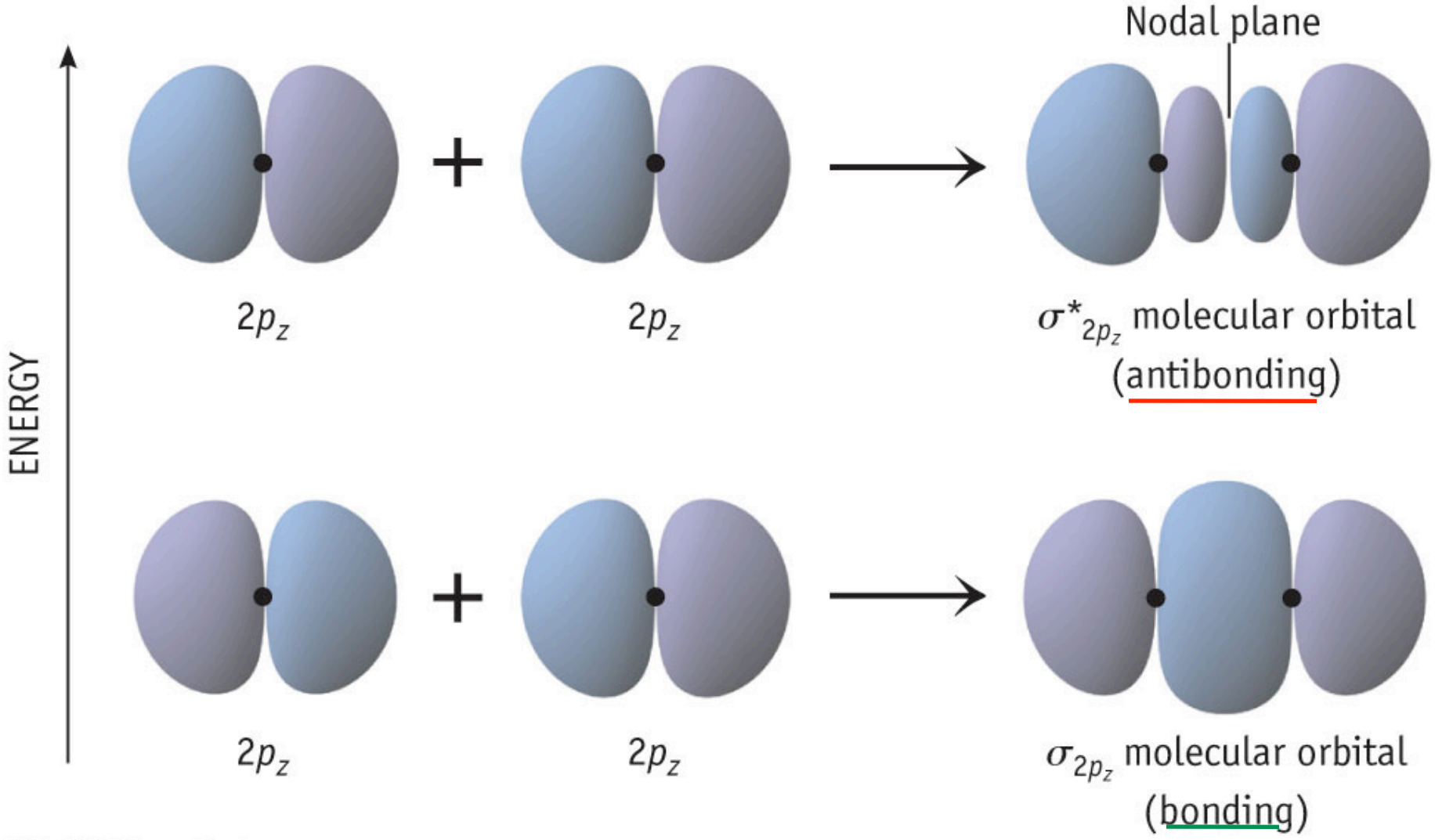


Fig. 9-19, p. 426

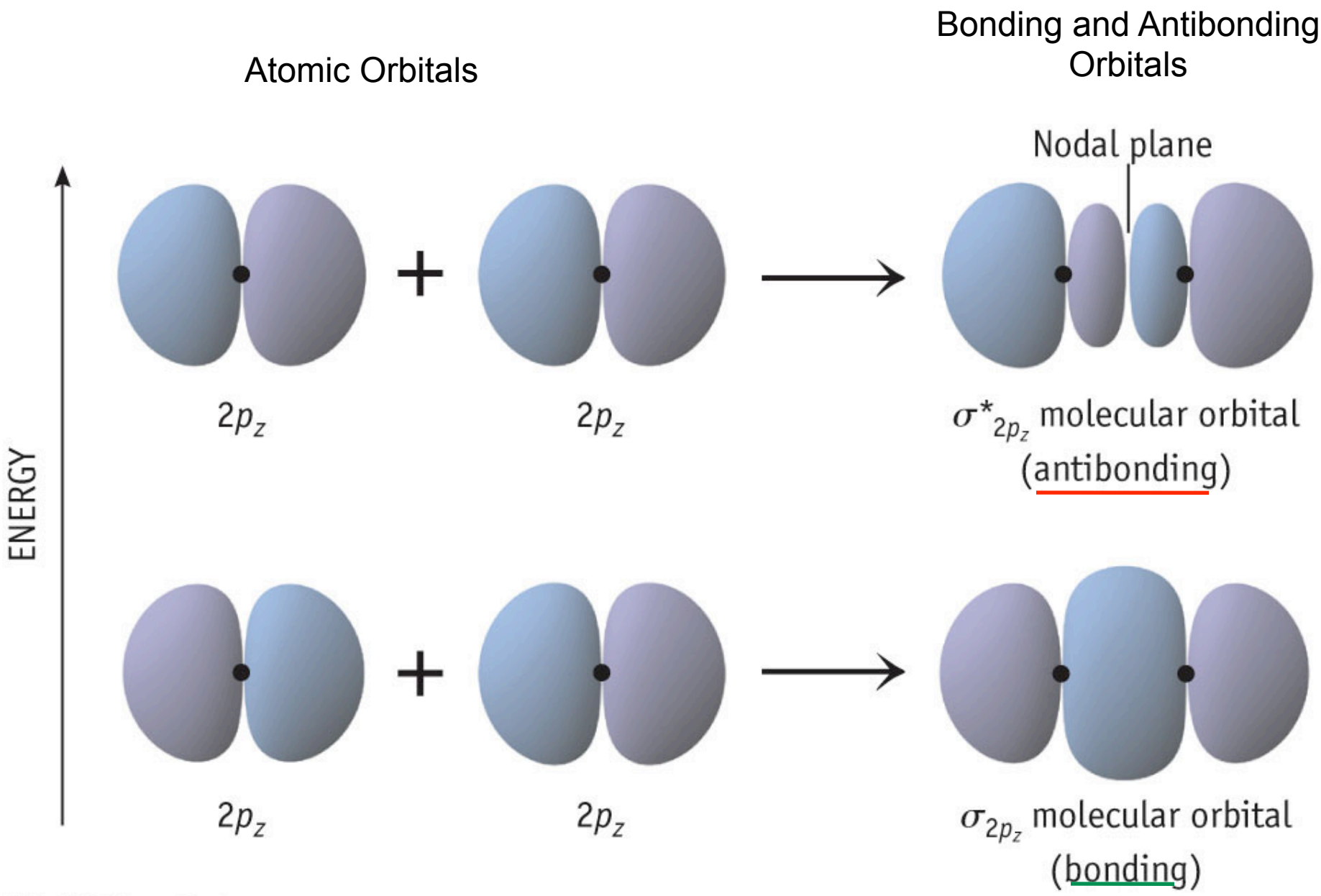


Fig. 9-19, p. 426

Sigma bonds

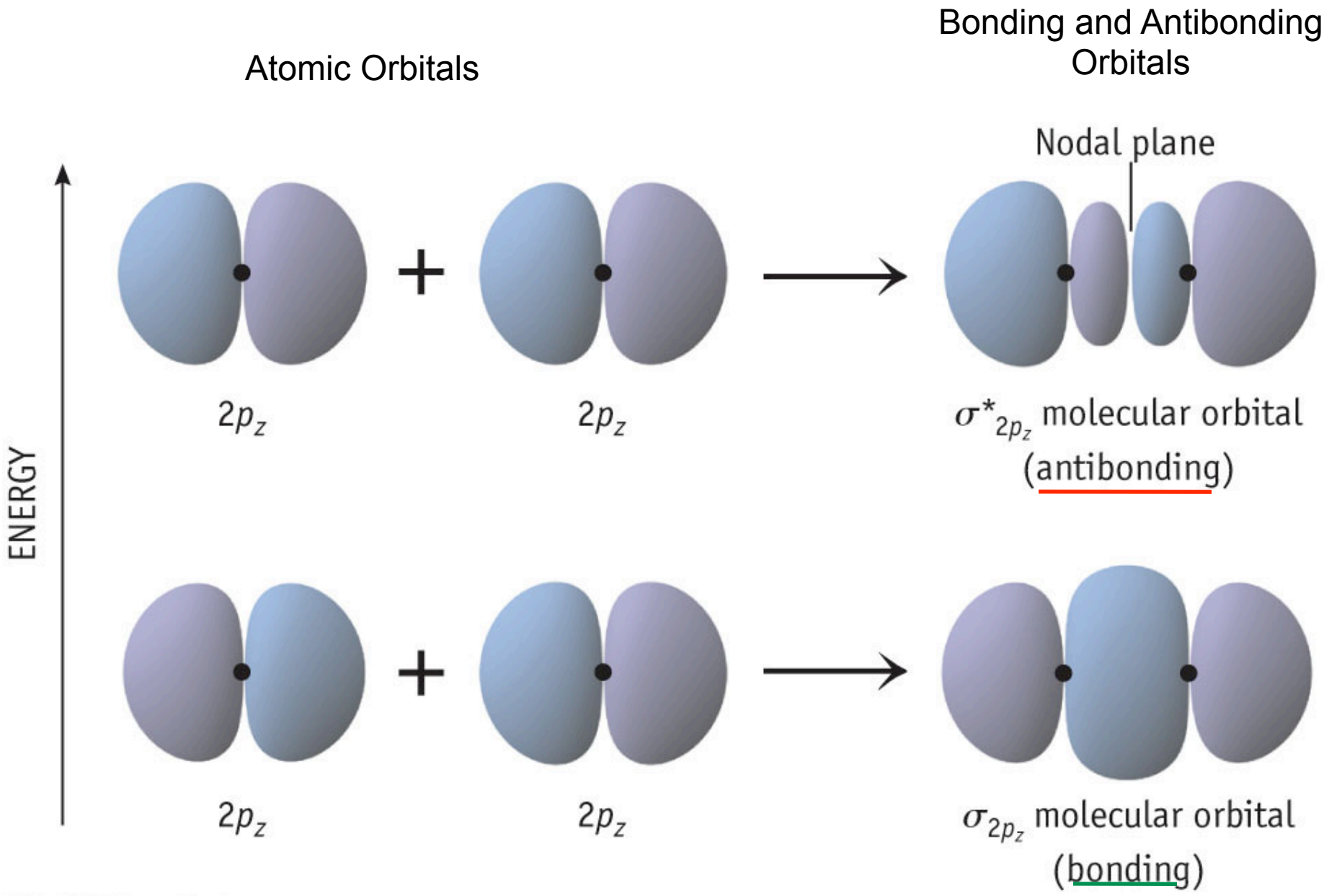
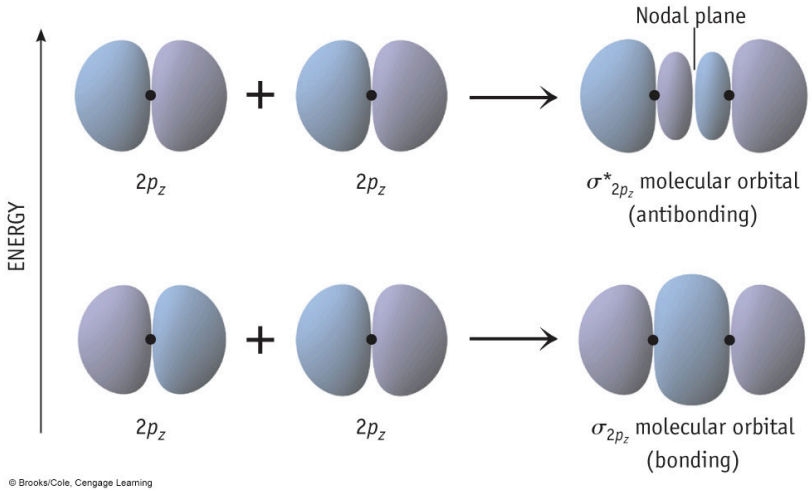
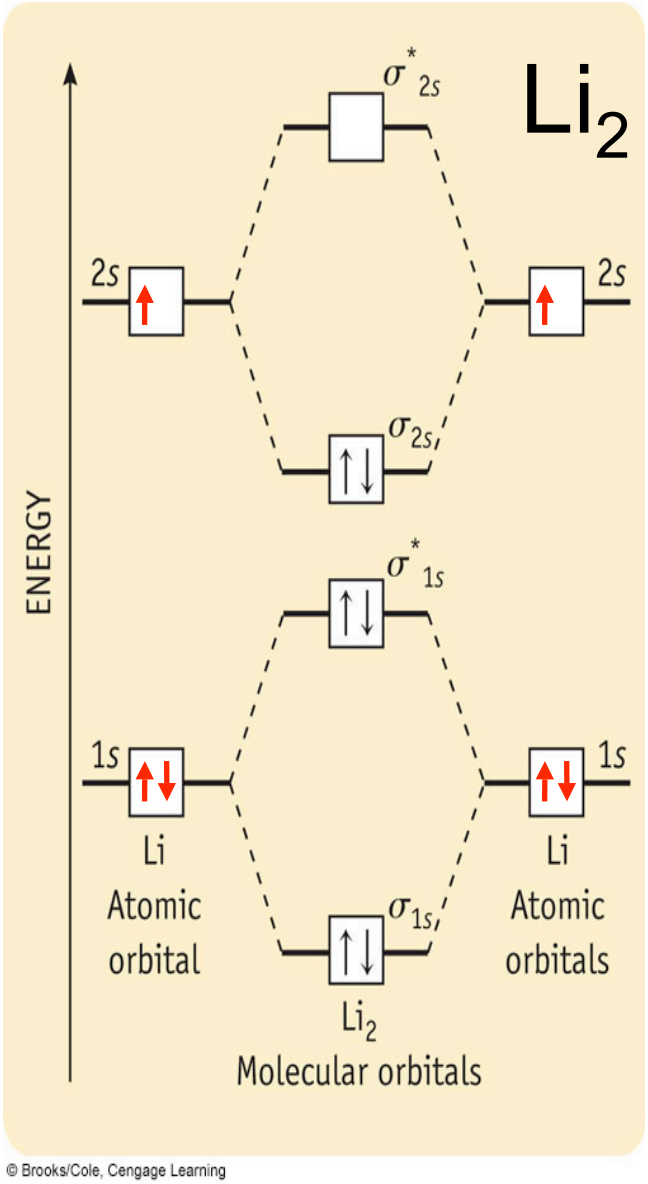


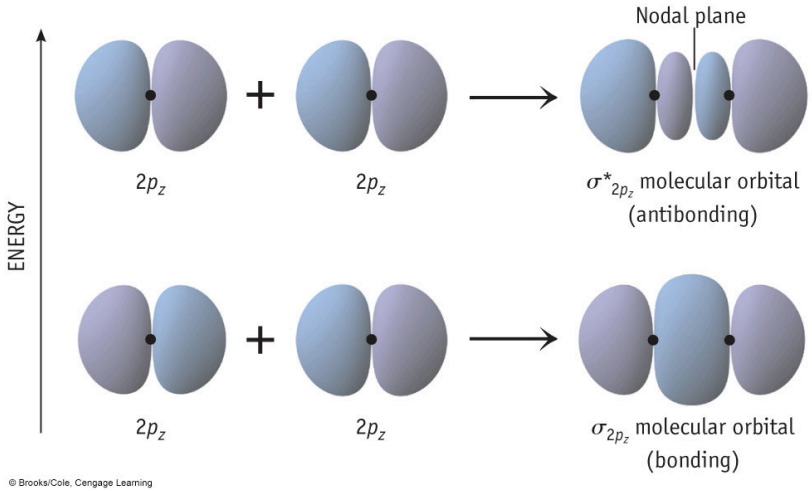
Fig. 9-19, p. 426





Li - $1s^2 2s^1$

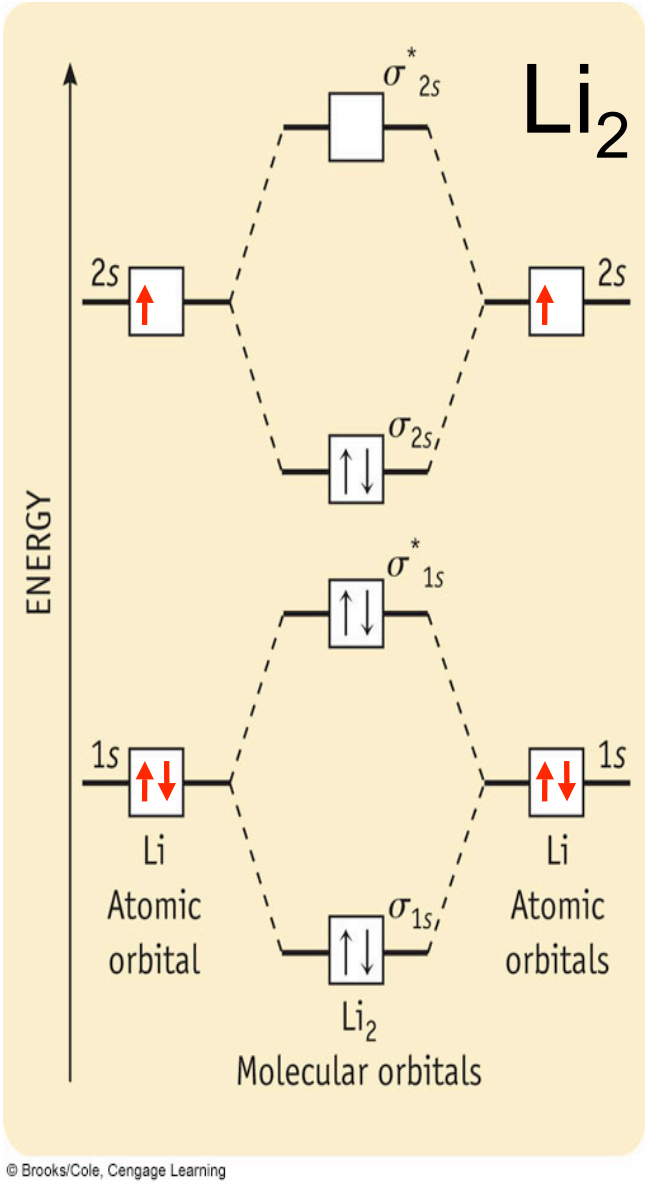
Fig. 9-18, p. 425



Why not hybrid atomic orbitals?

Not worth it in diatomics

But we will in everything larger



Li - $1s^2 2s^1$

Fig. 9-18, p. 425

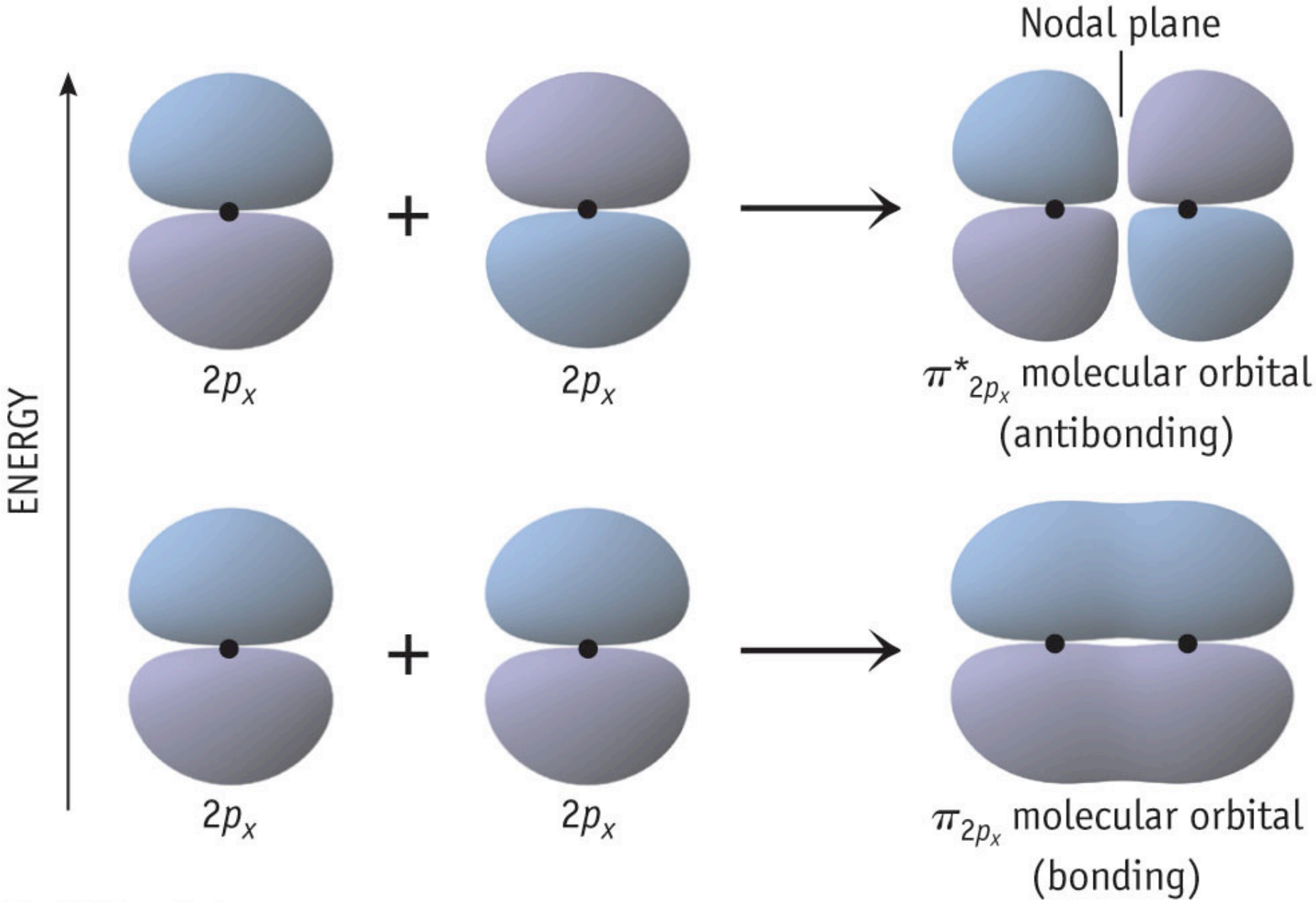


Fig. 9-20, p. 427

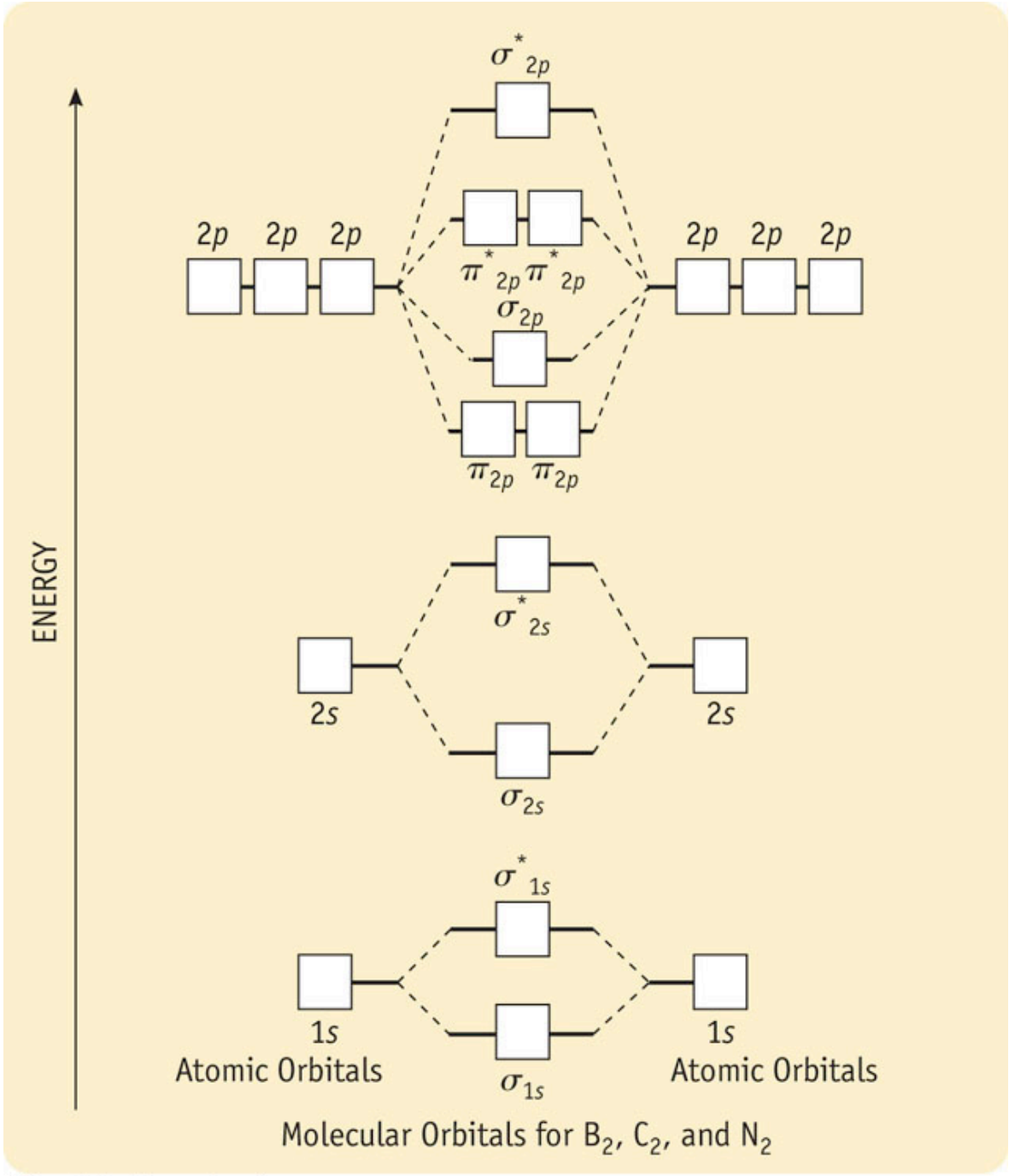
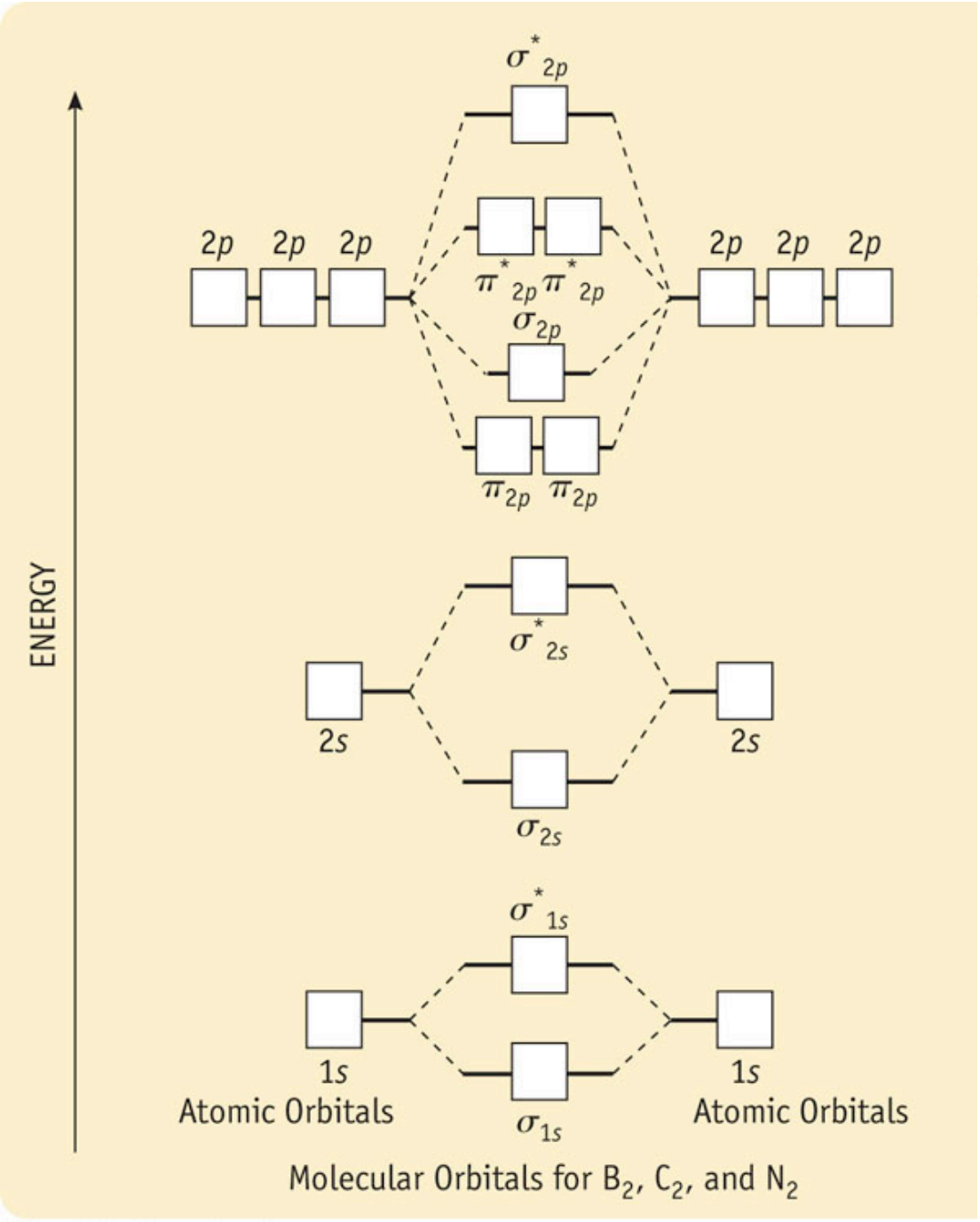
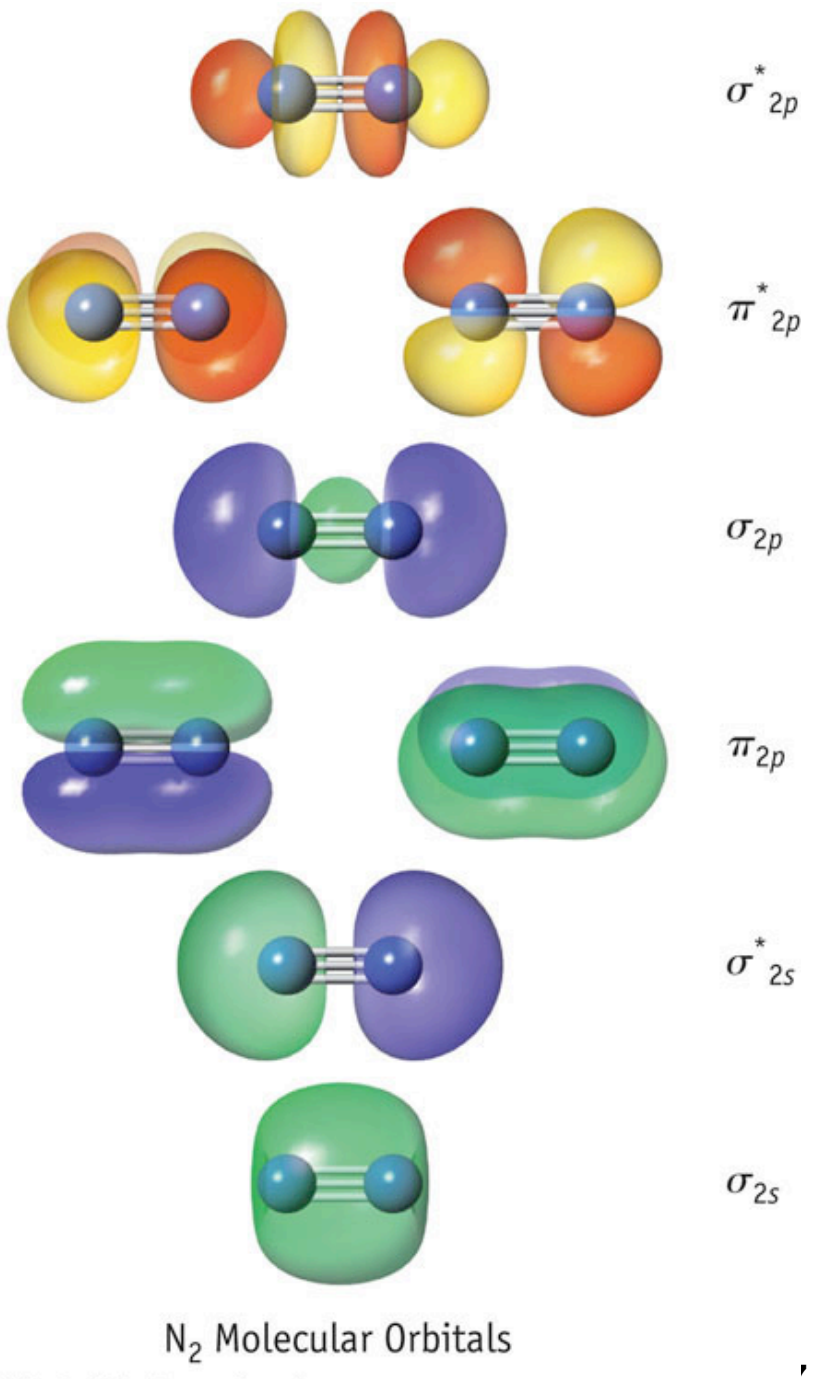


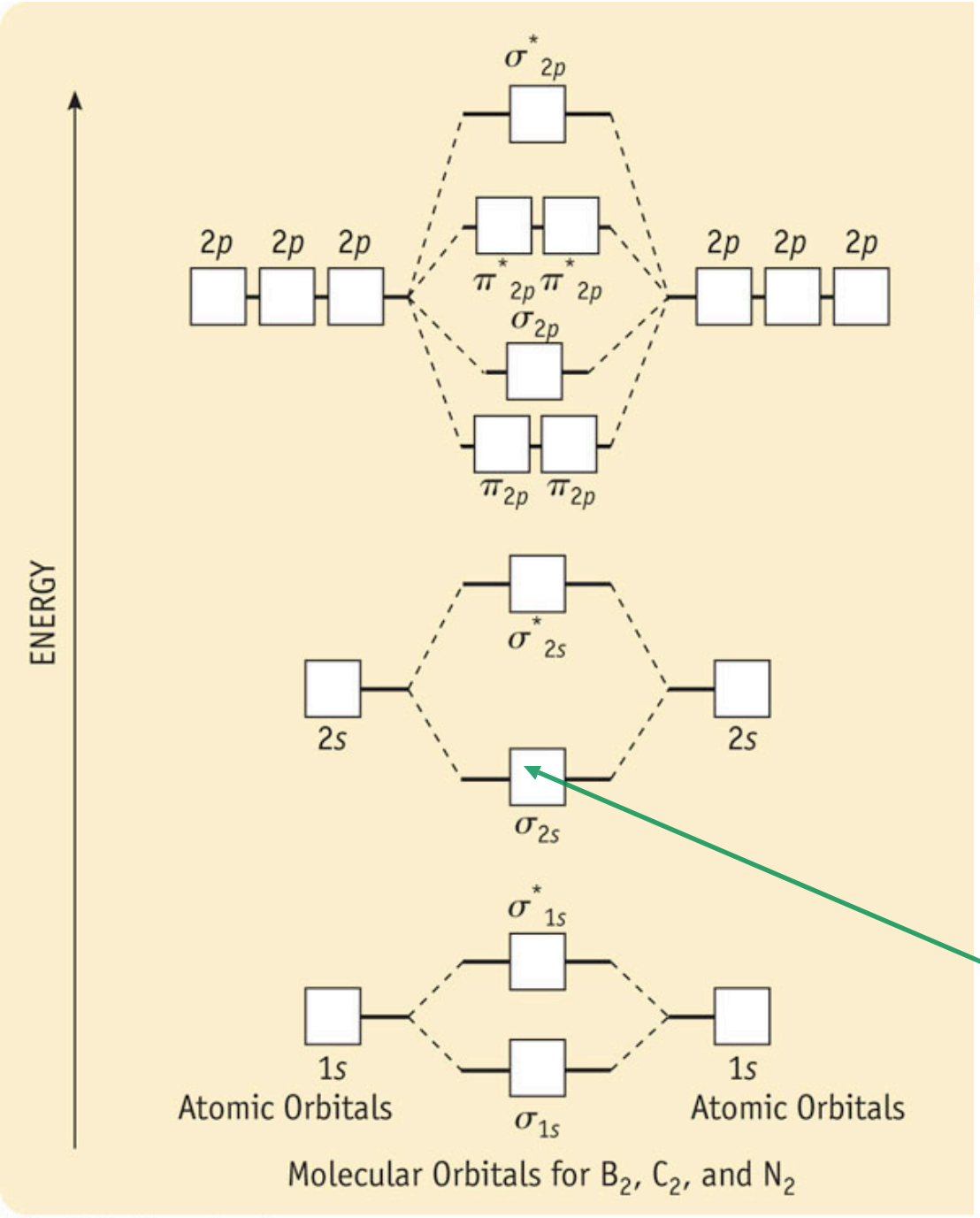
Fig. 9-21a, p. 427



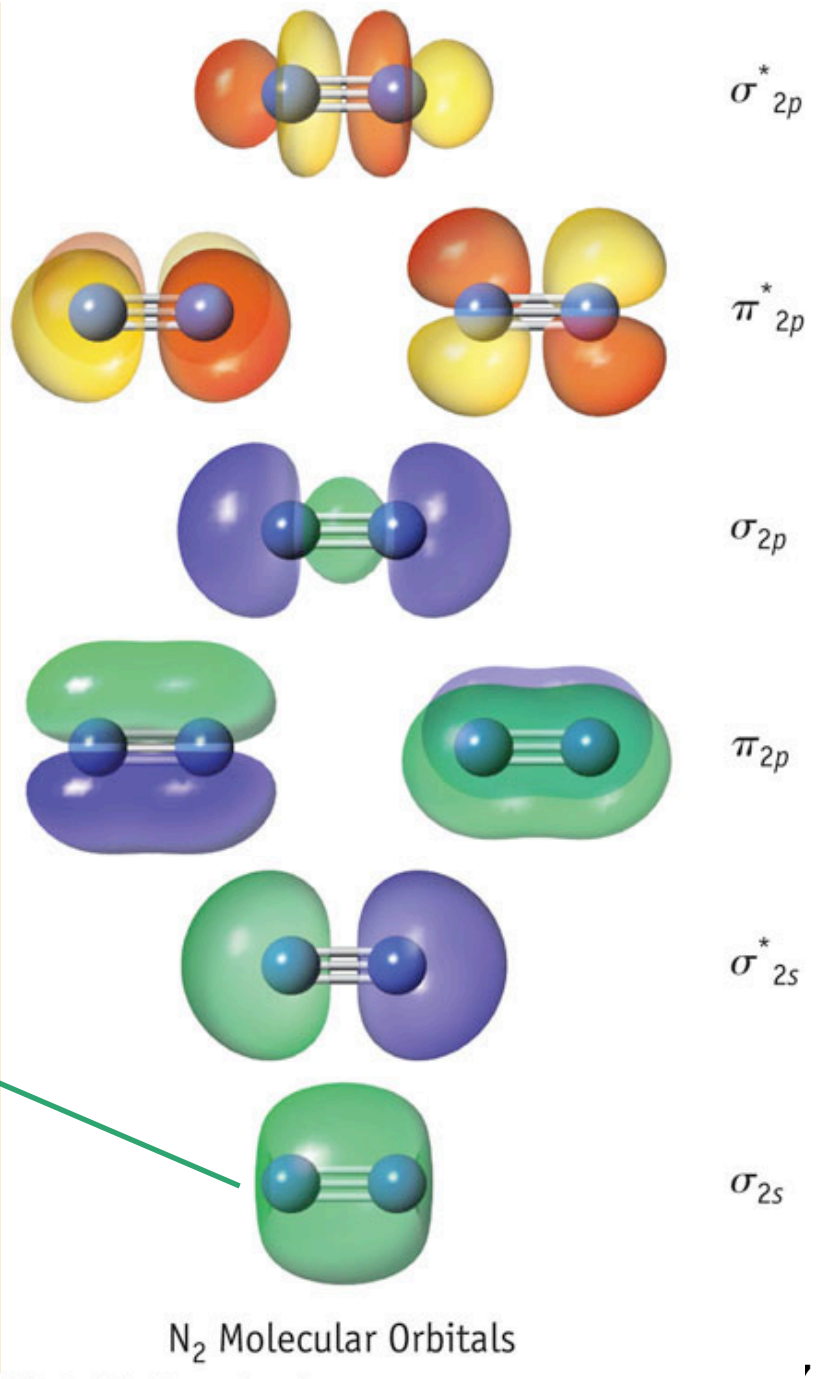
Molecular Orbitals for B_2, C_2, and N_2



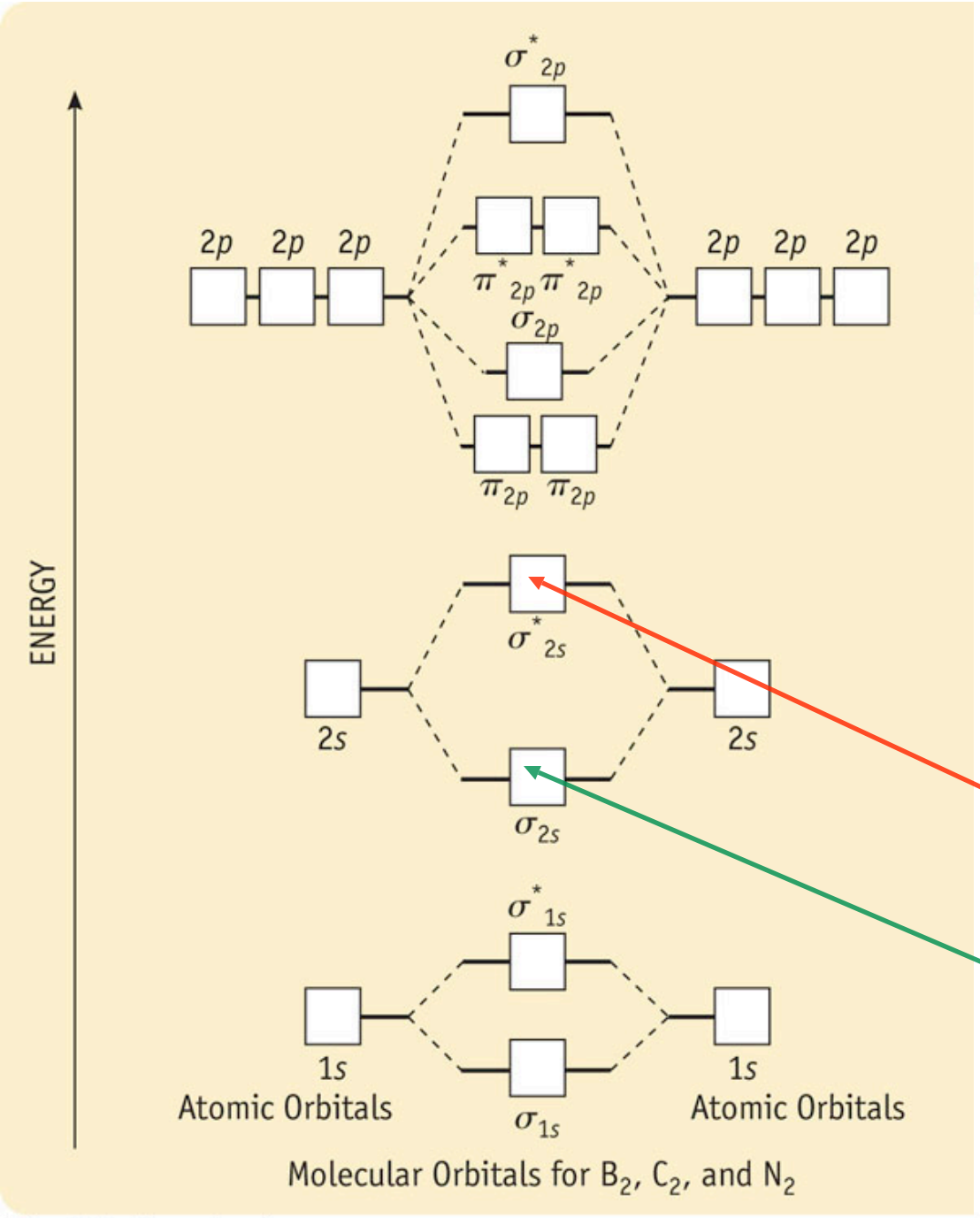
N_2 Molecular Orbitals



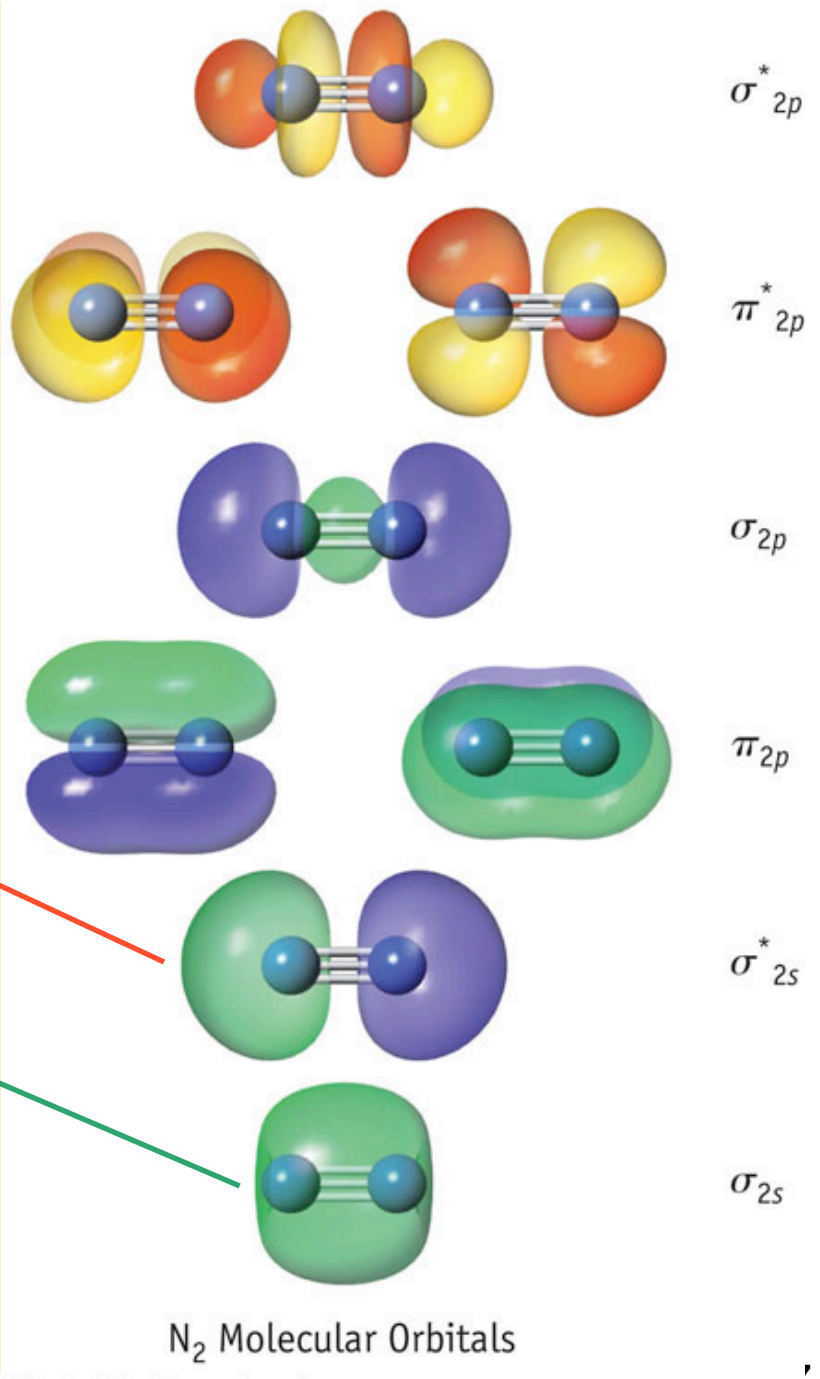
Molecular Orbitals for B_2, C_2, and N_2



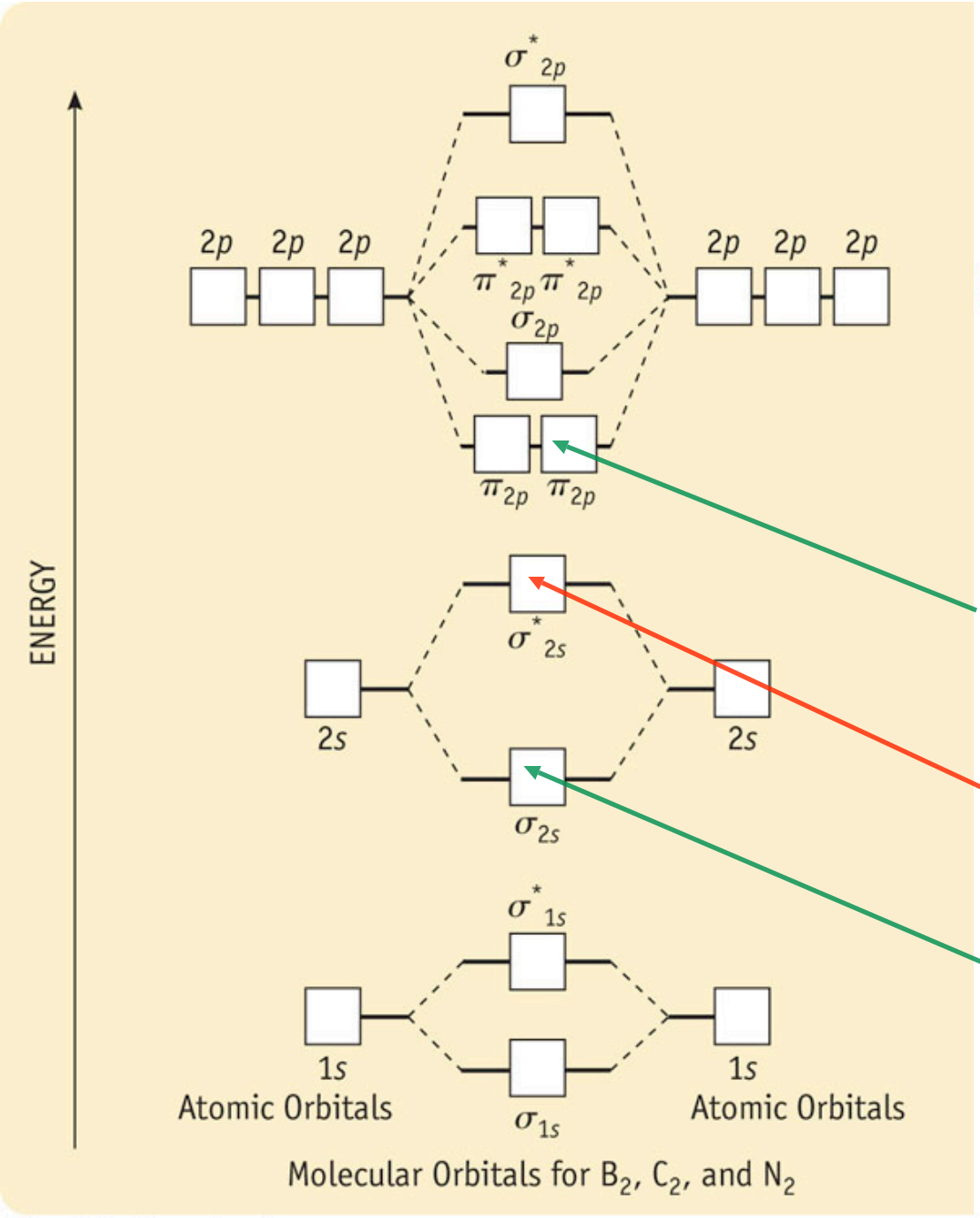
N_2 Molecular Orbitals



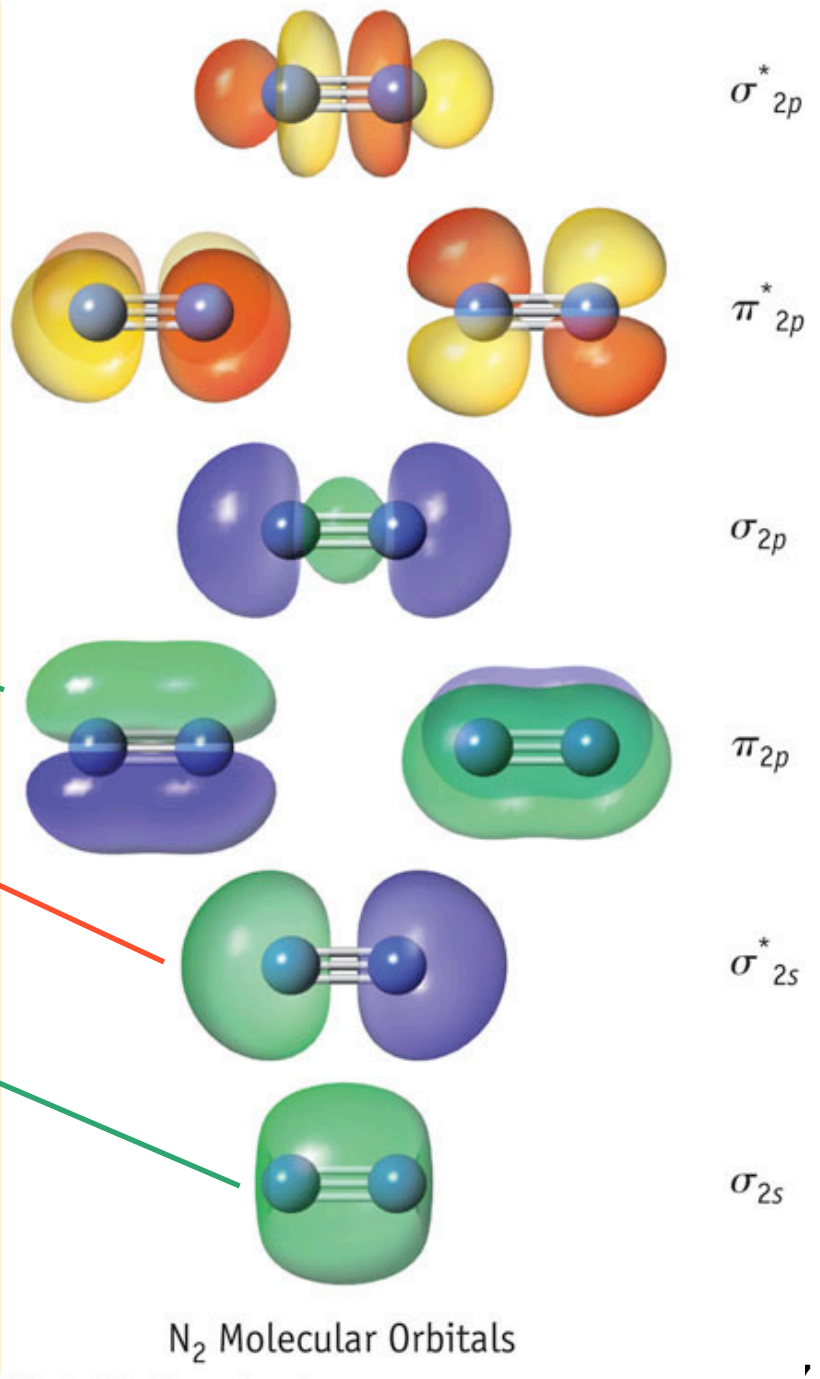
Molecular Orbitals for B_2, C_2, and N_2



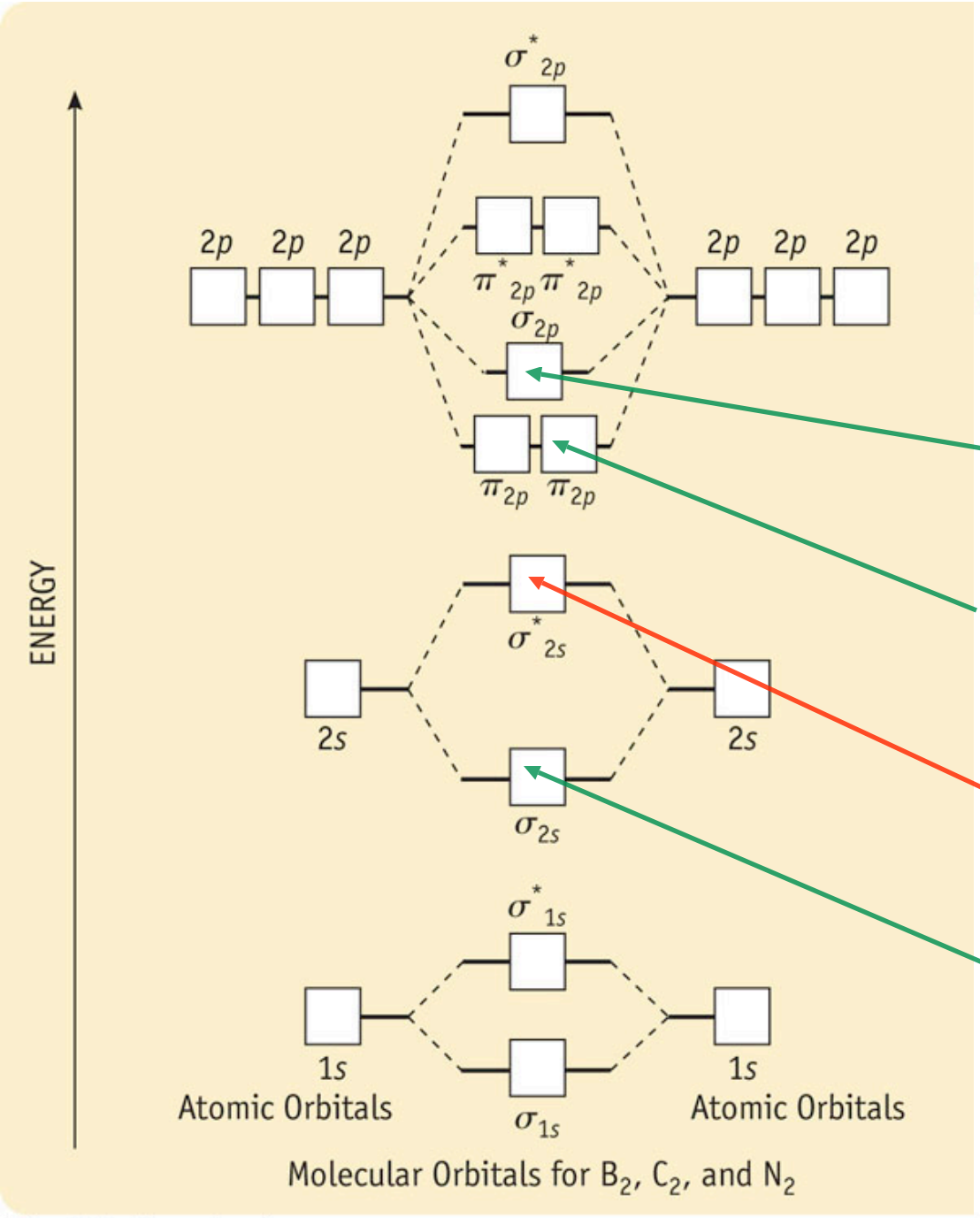
N_2 Molecular Orbitals



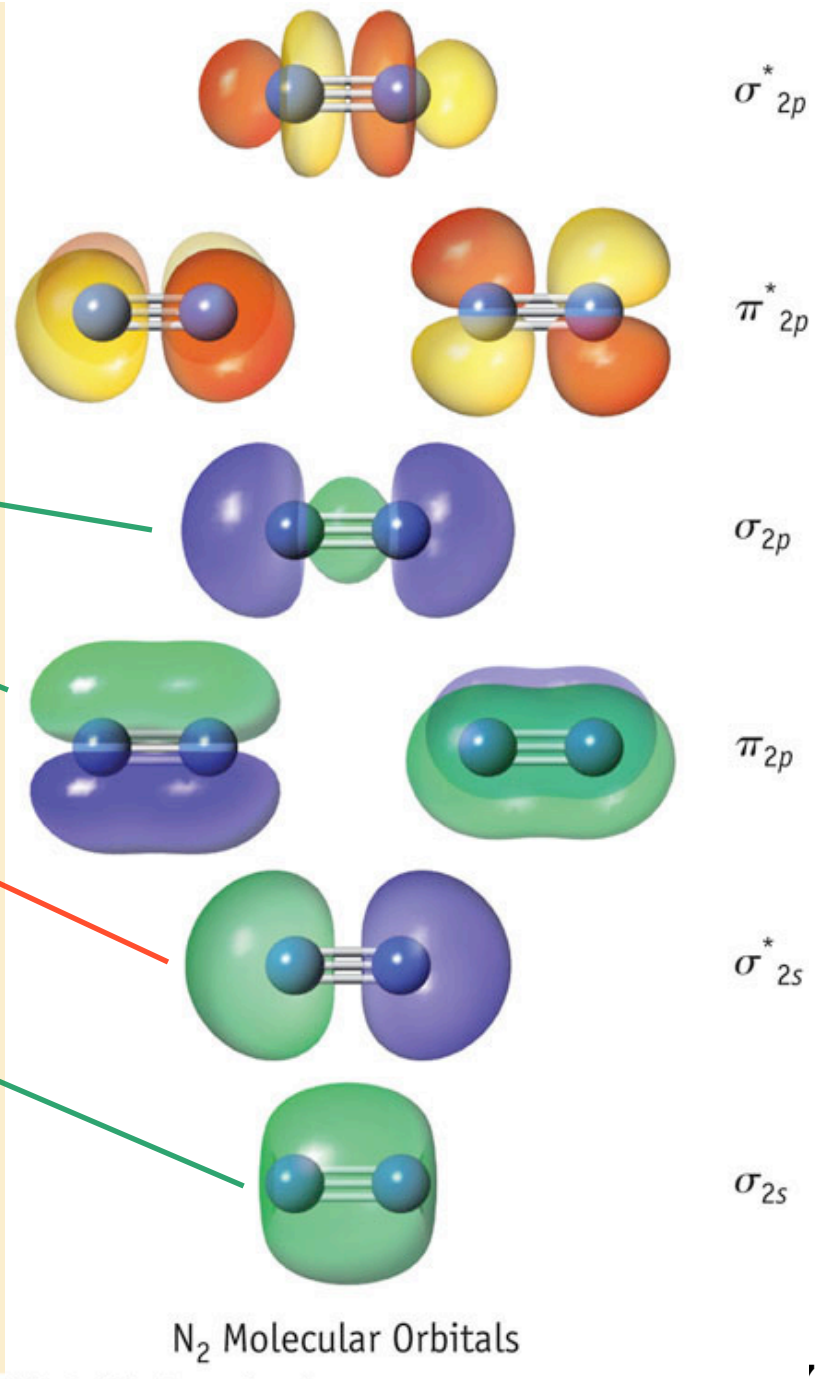
Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals



Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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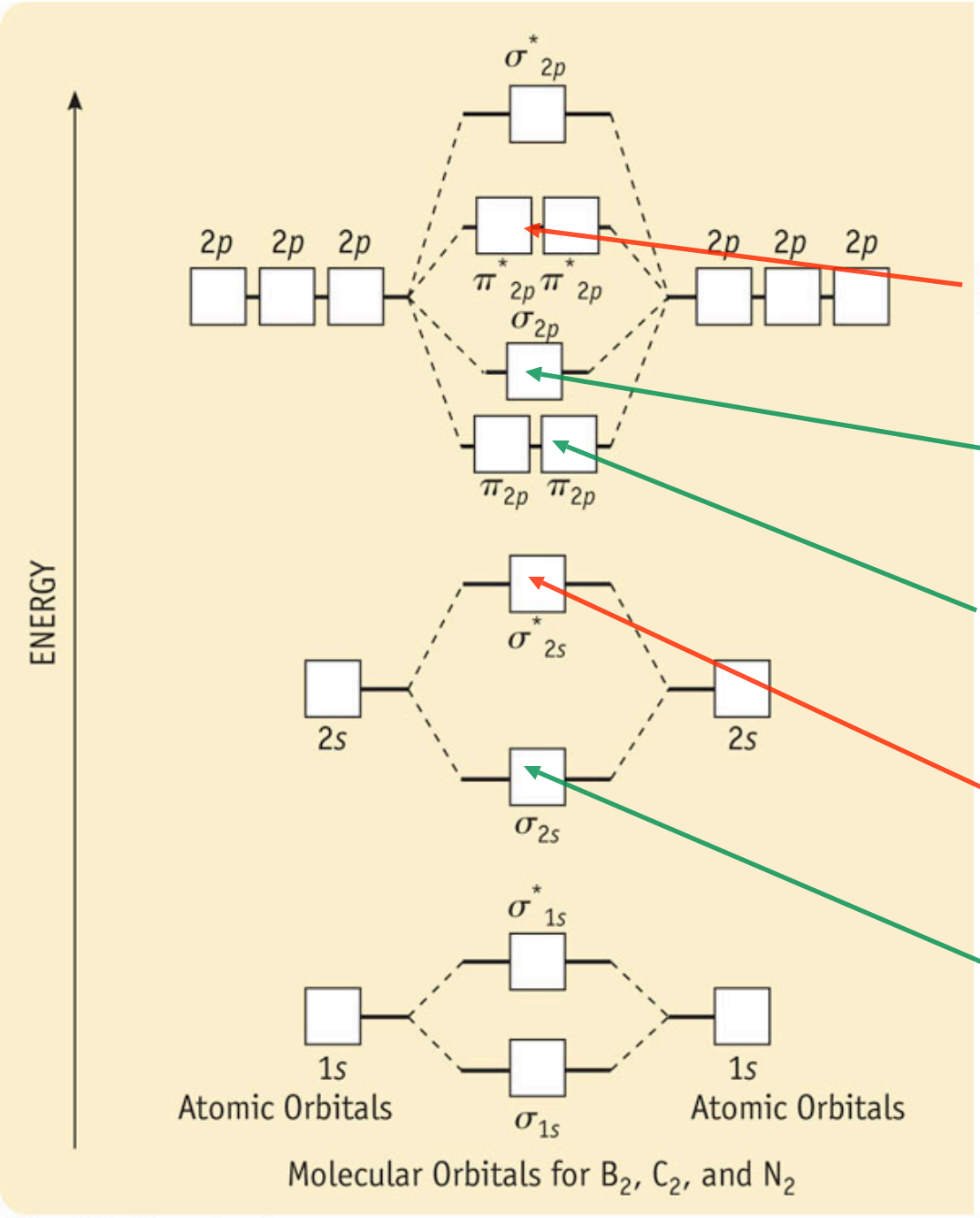
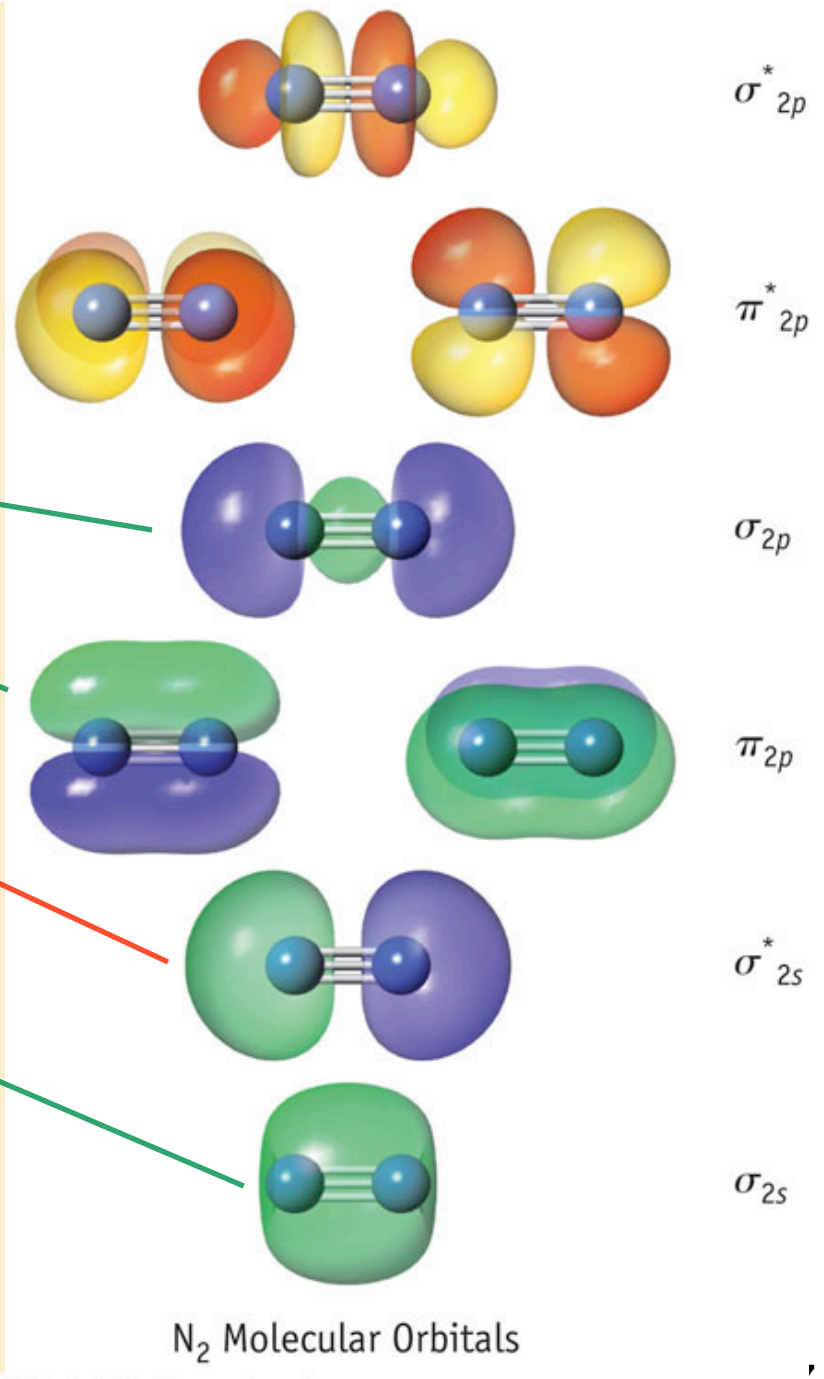


Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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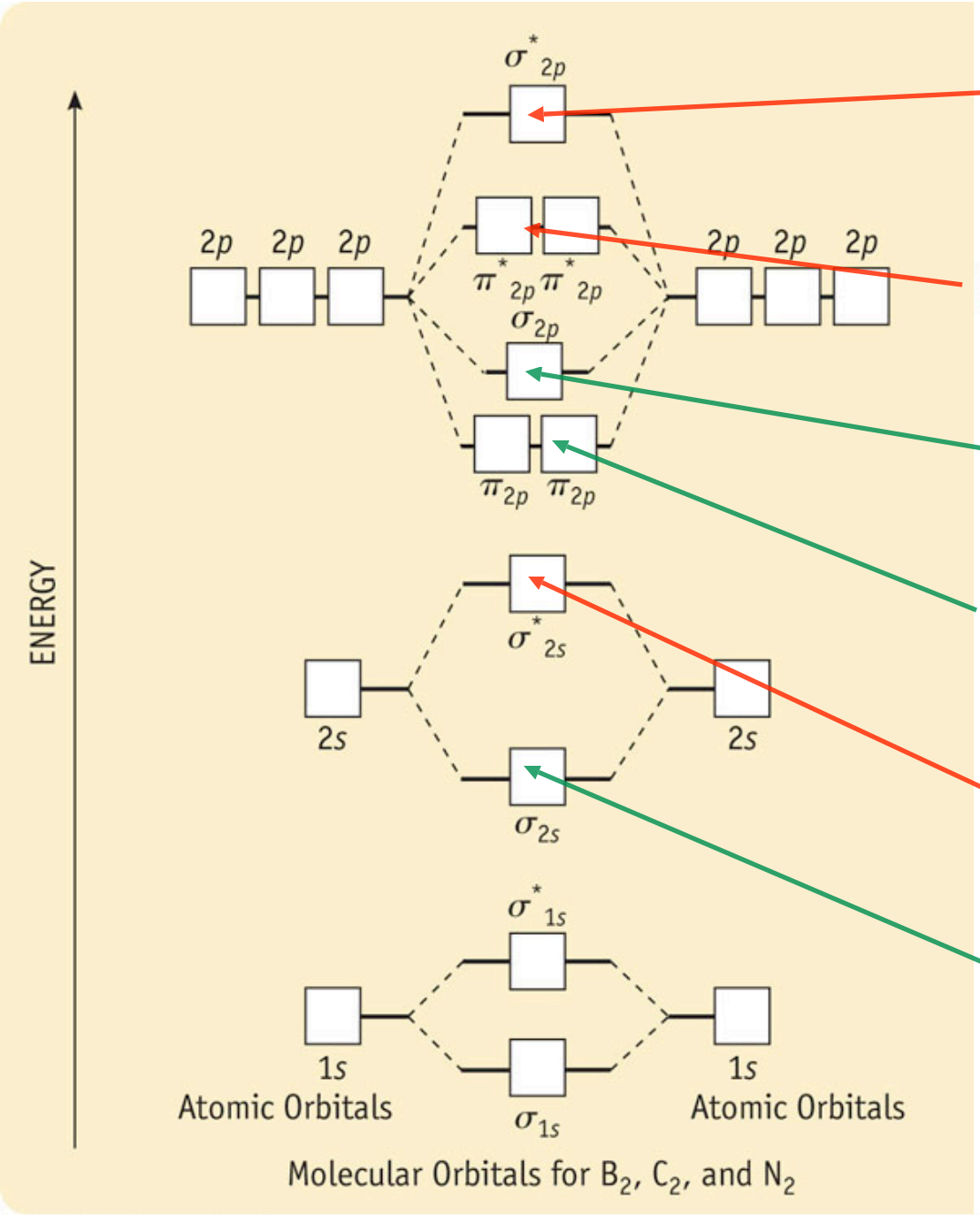
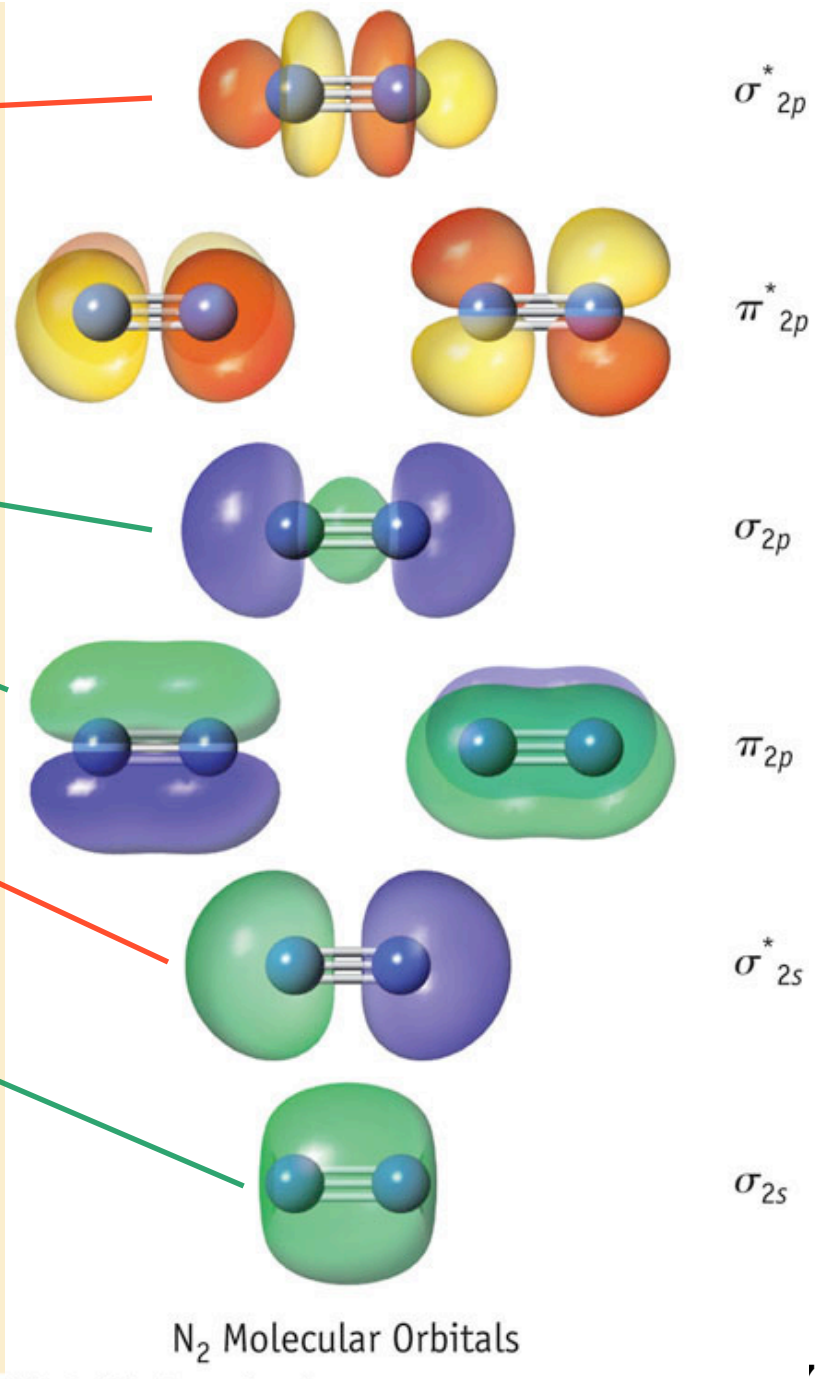


Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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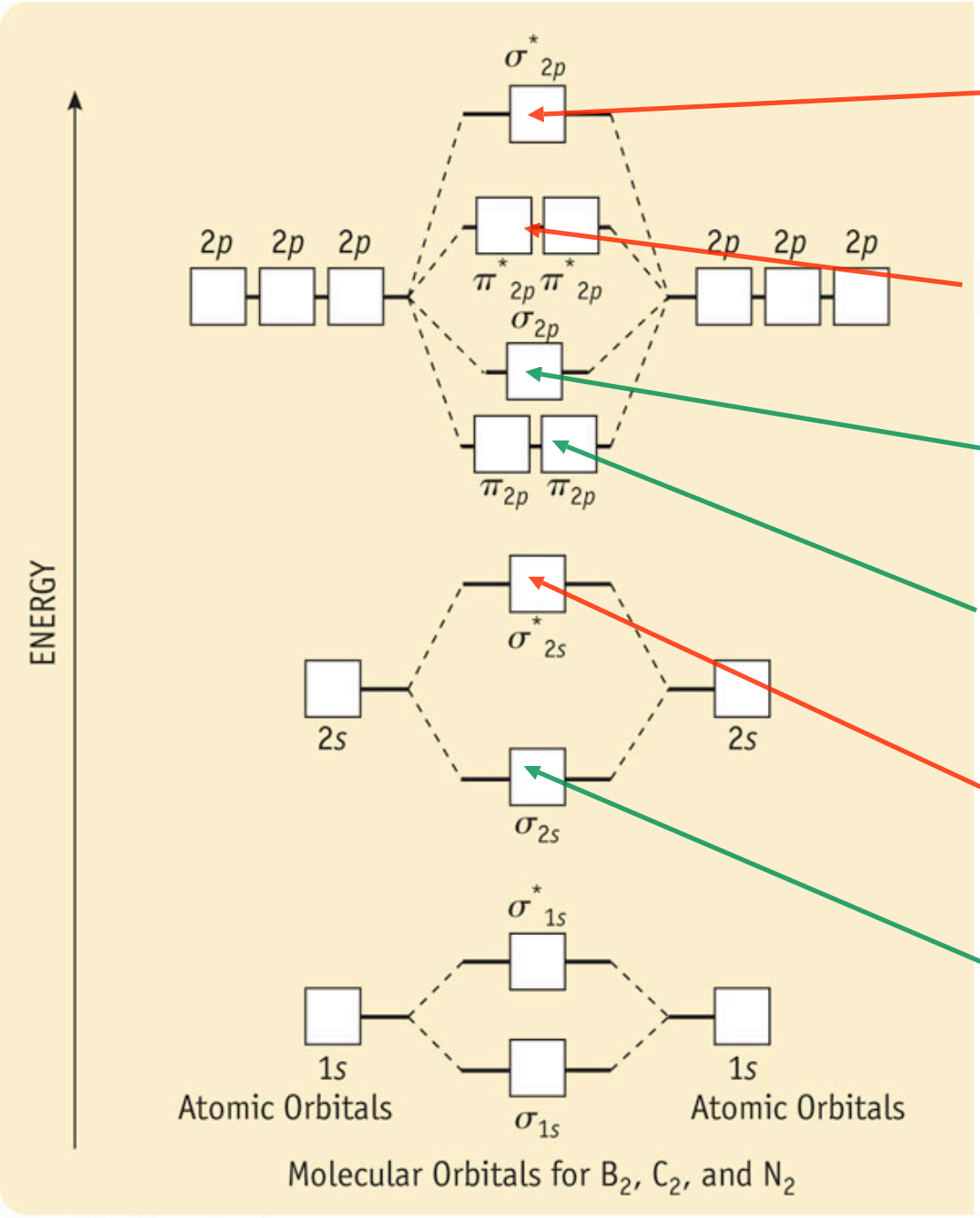
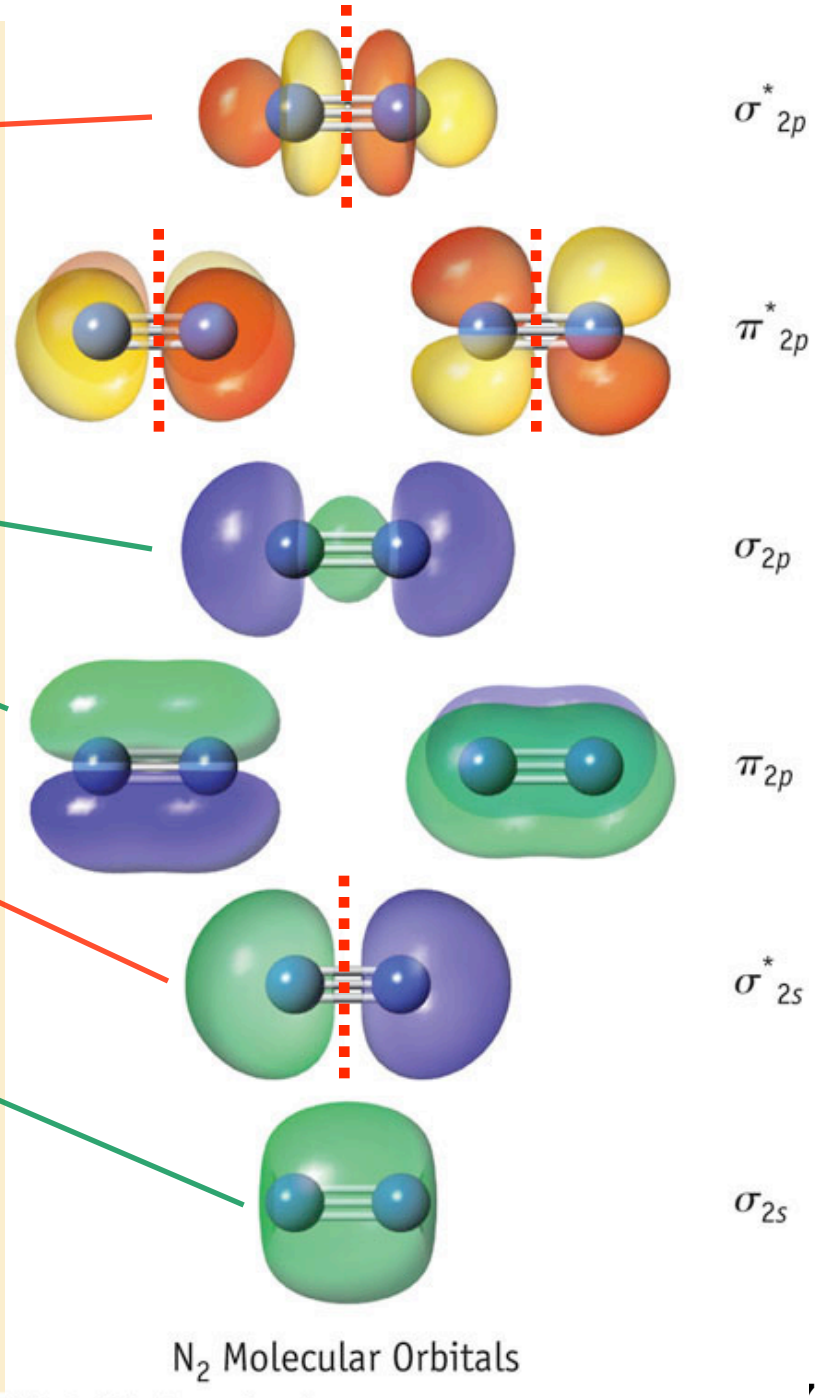


Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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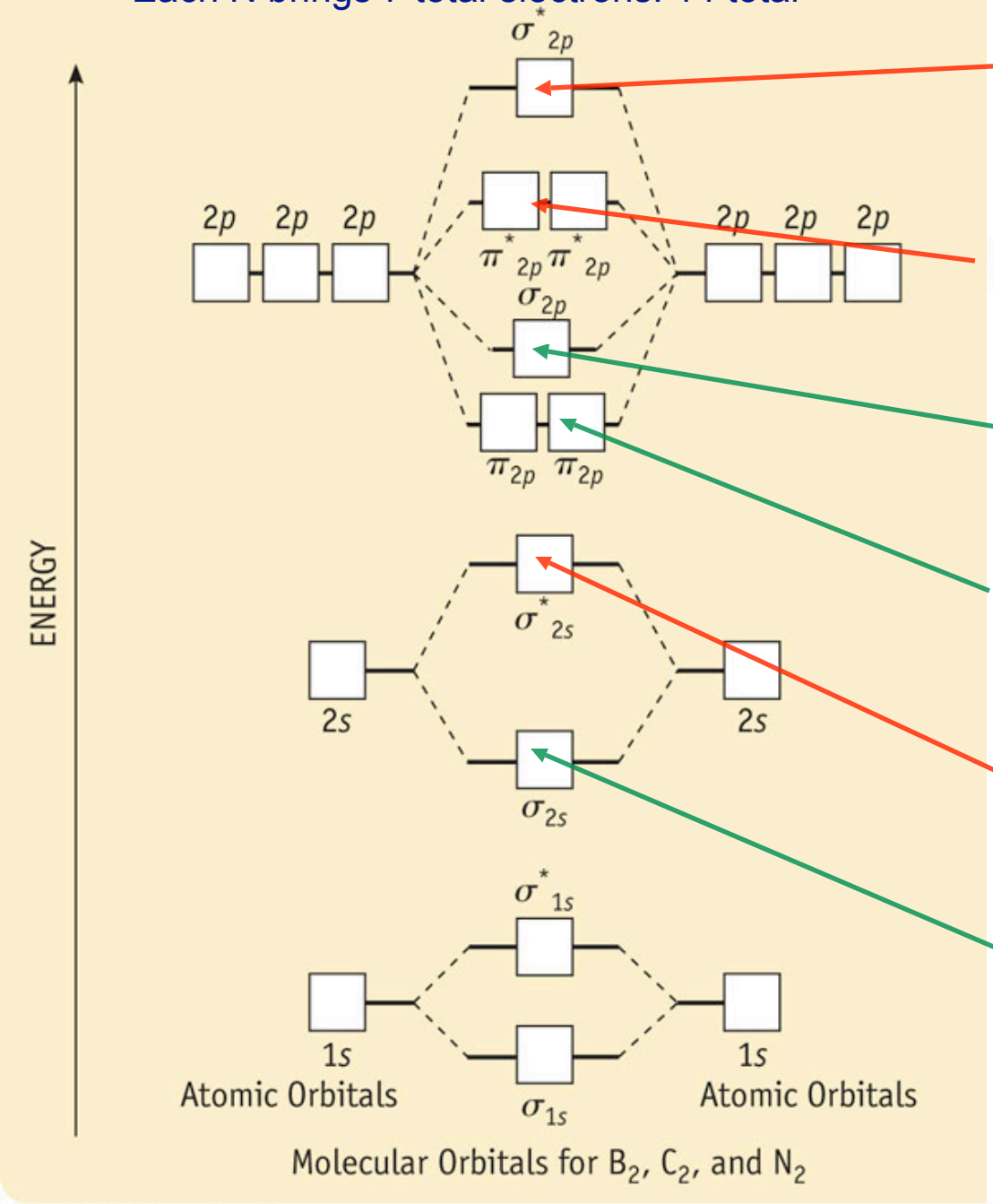
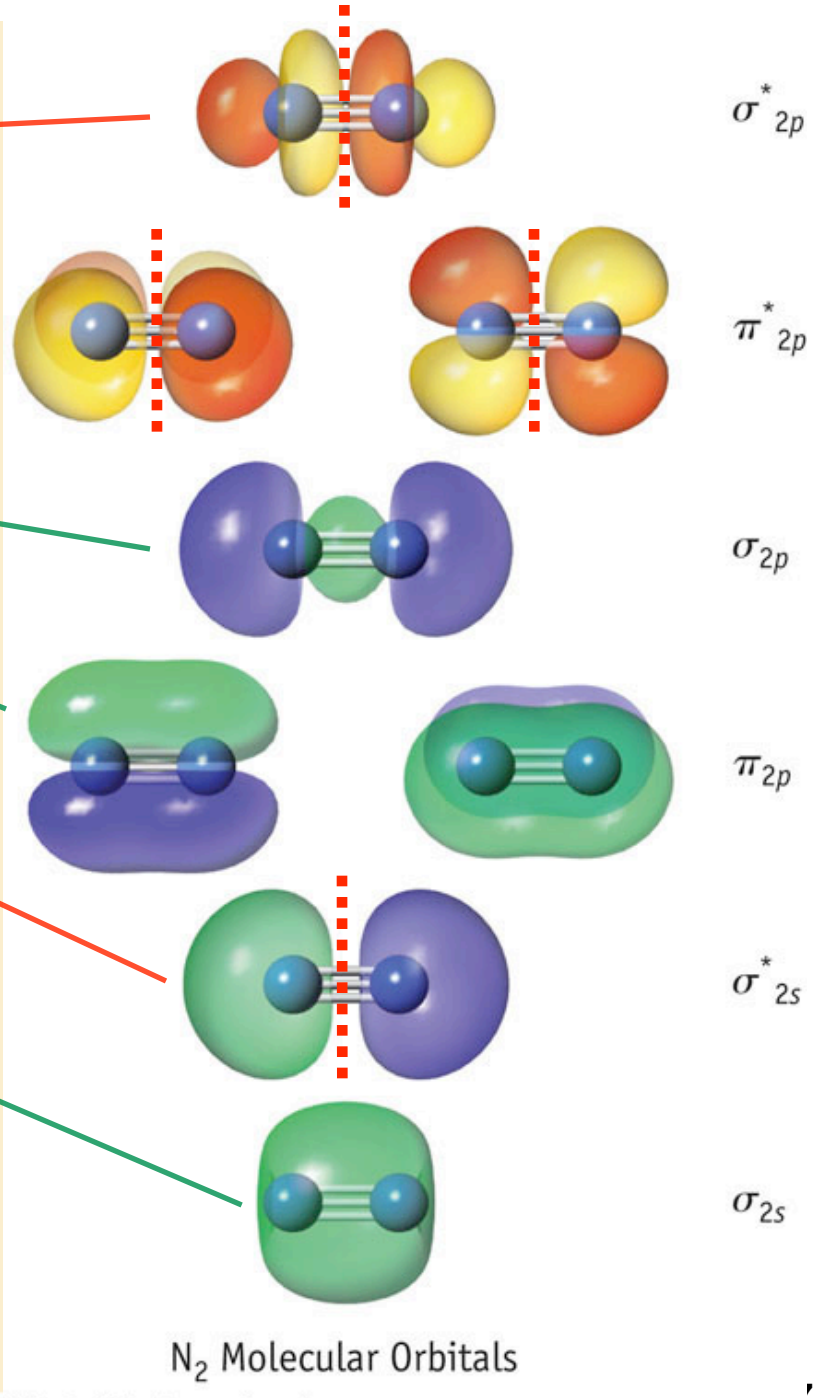
Each N brings 7 total electrons: 14 total



Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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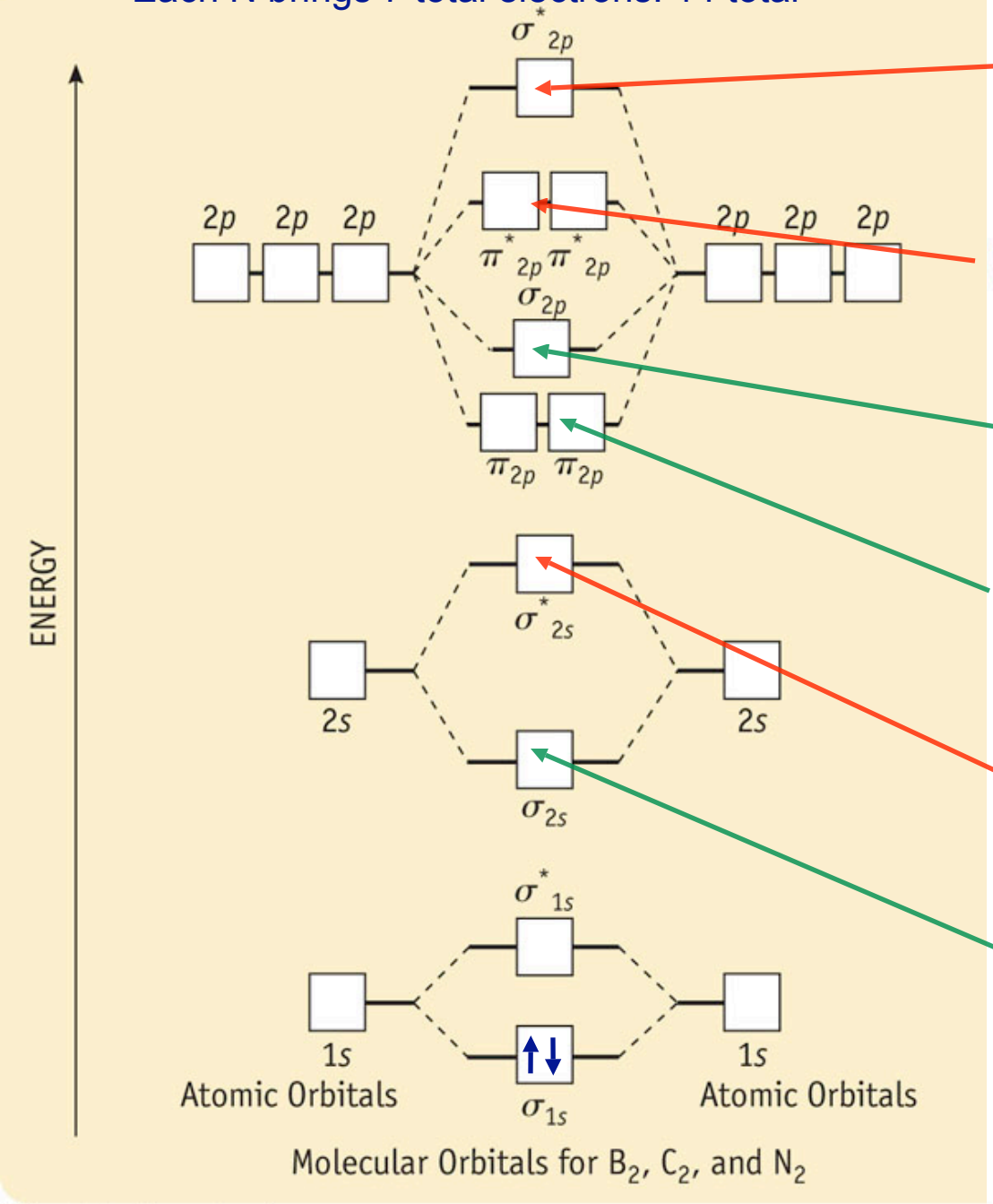
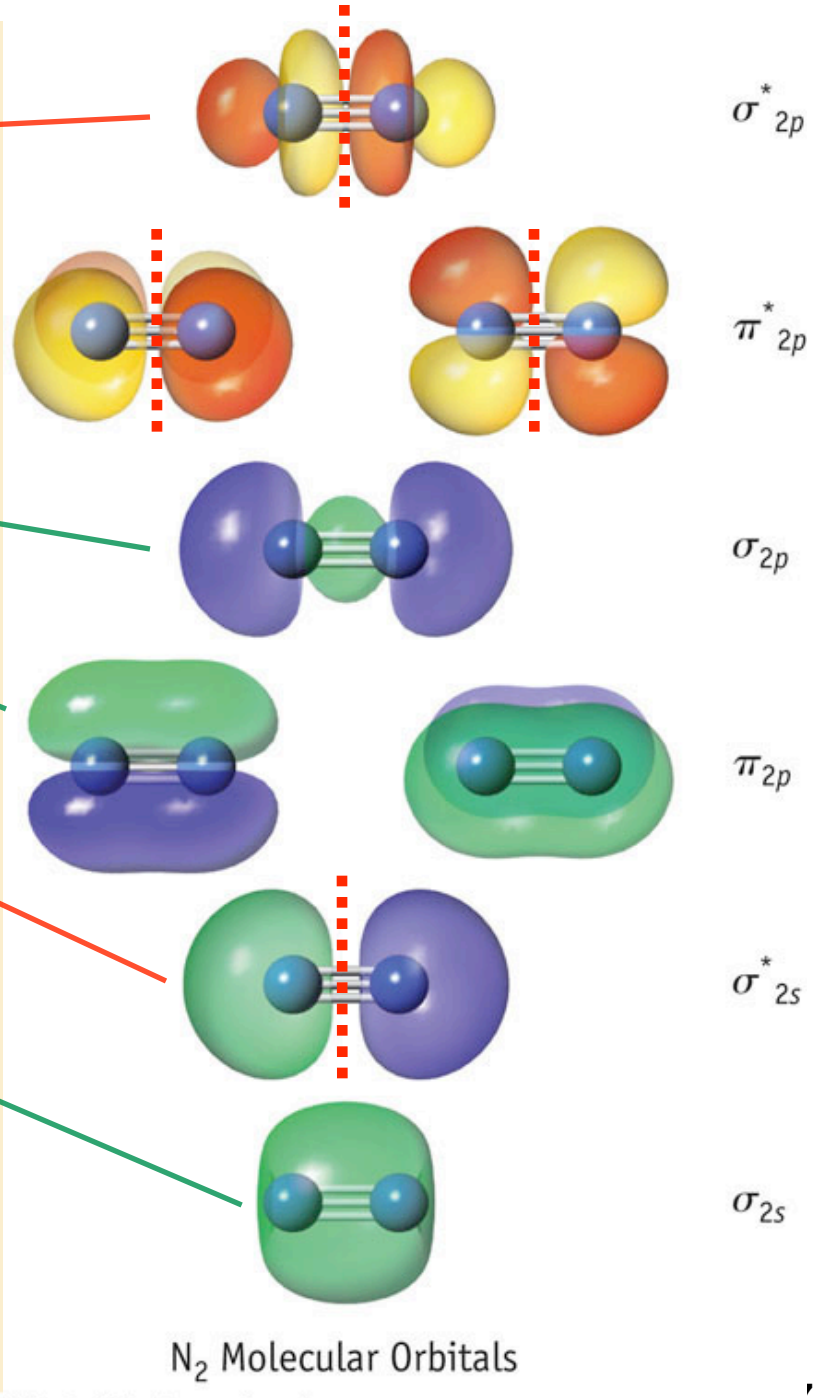
Each N brings 7 total electrons: 14 total



Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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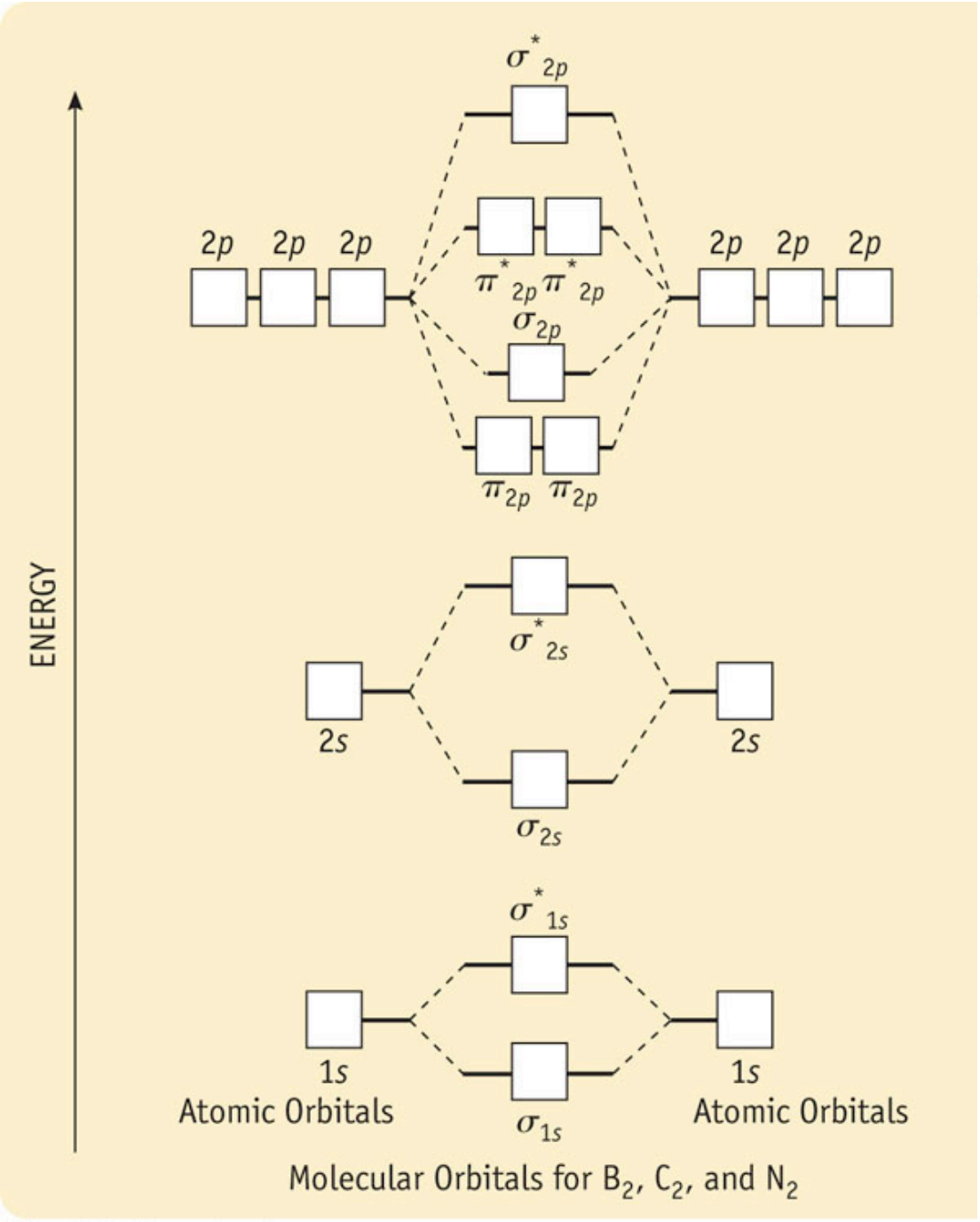
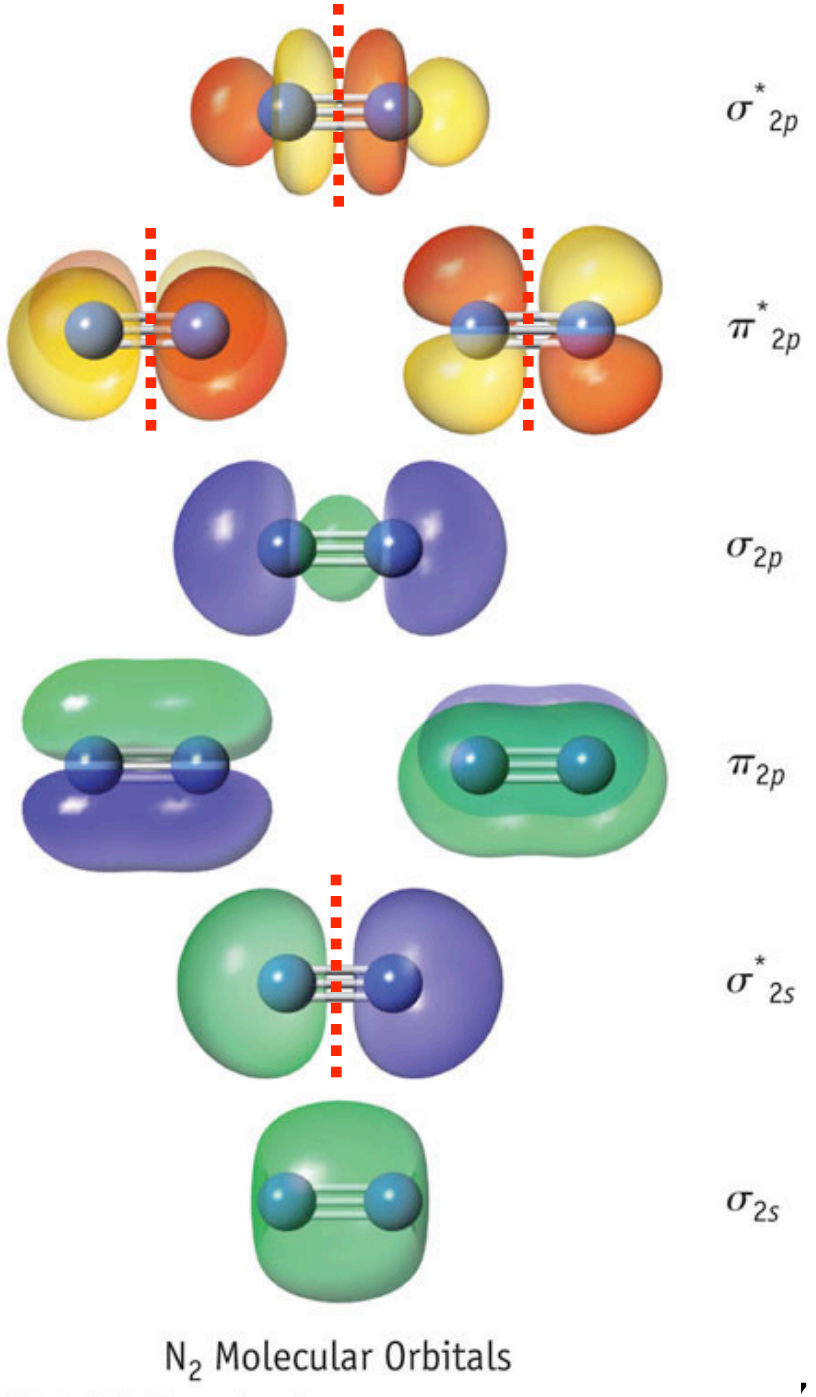
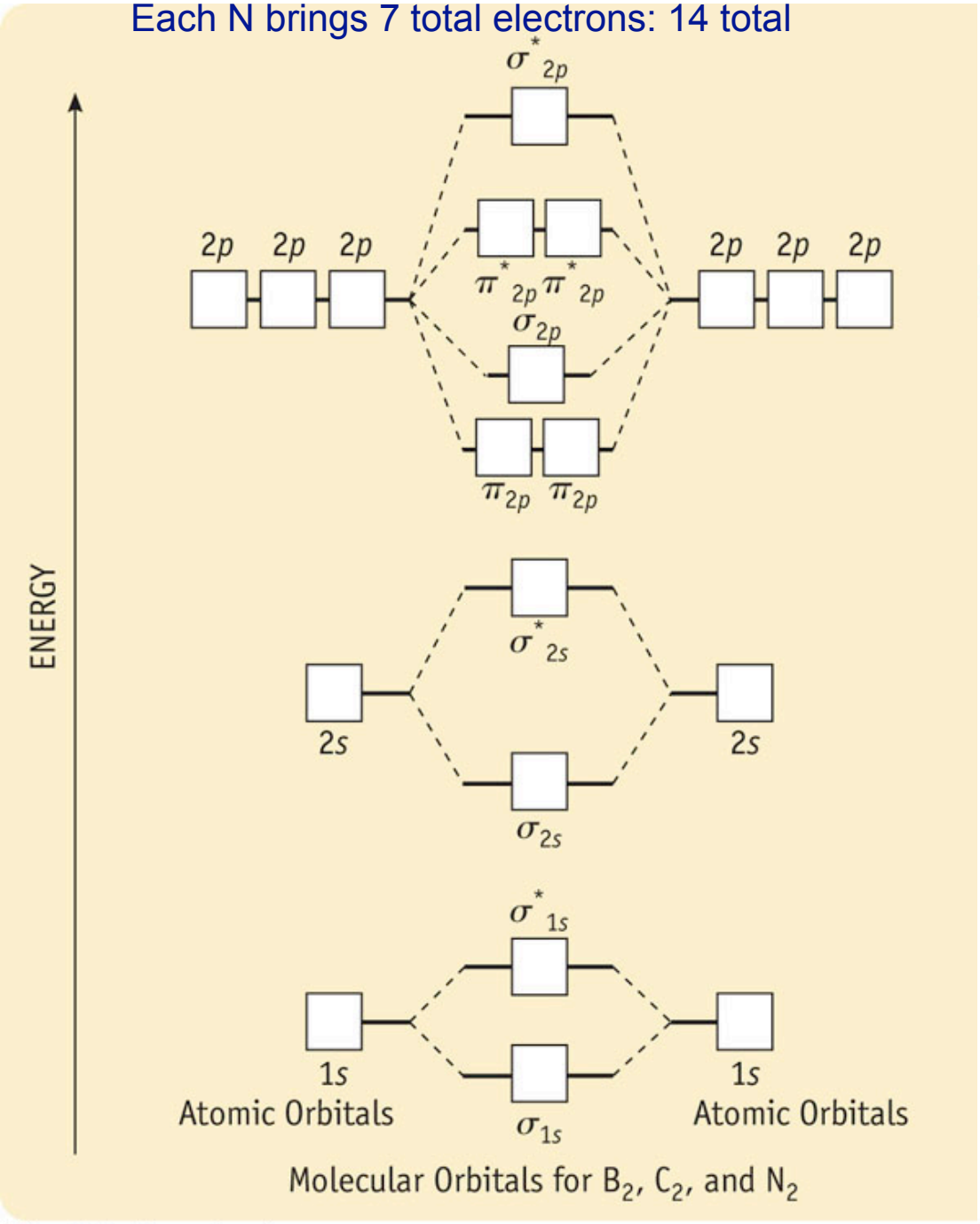


Molecular Orbitals for B_2, C_2, and N_2

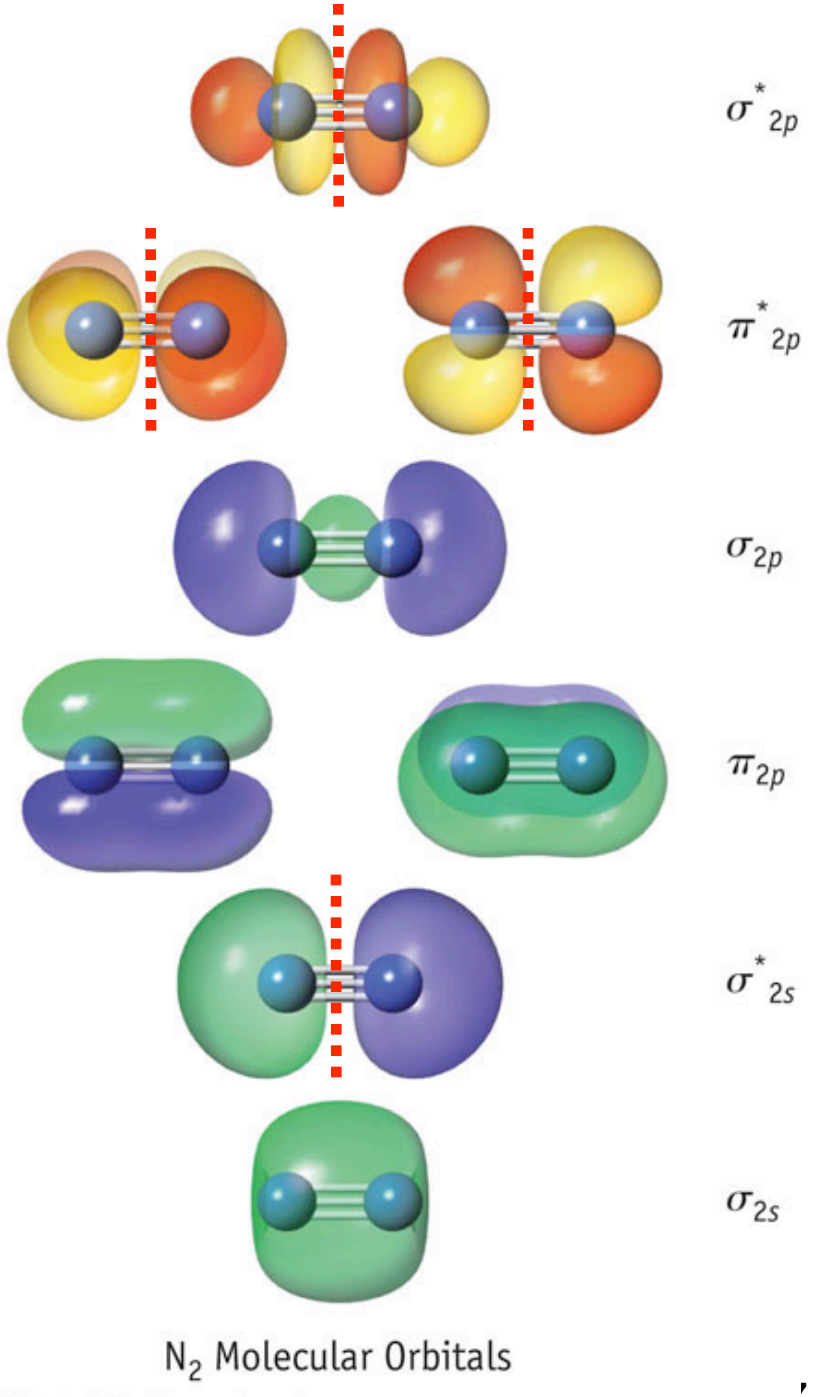


N_2 Molecular Orbitals

Each N brings 7 total electrons: 14 total



Molecular Orbitals for B_2, C_2, and N_2



N_2 Molecular Orbitals

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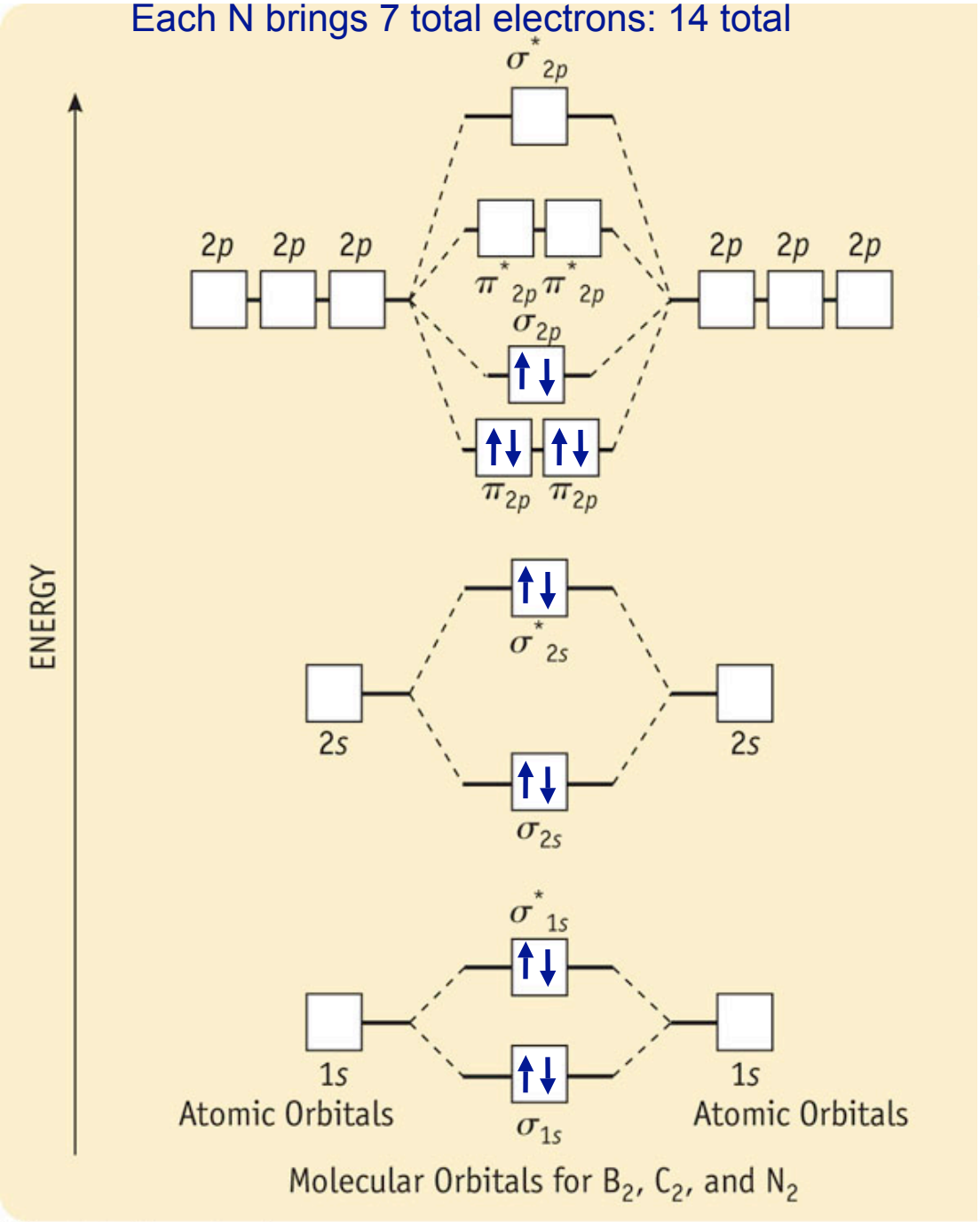
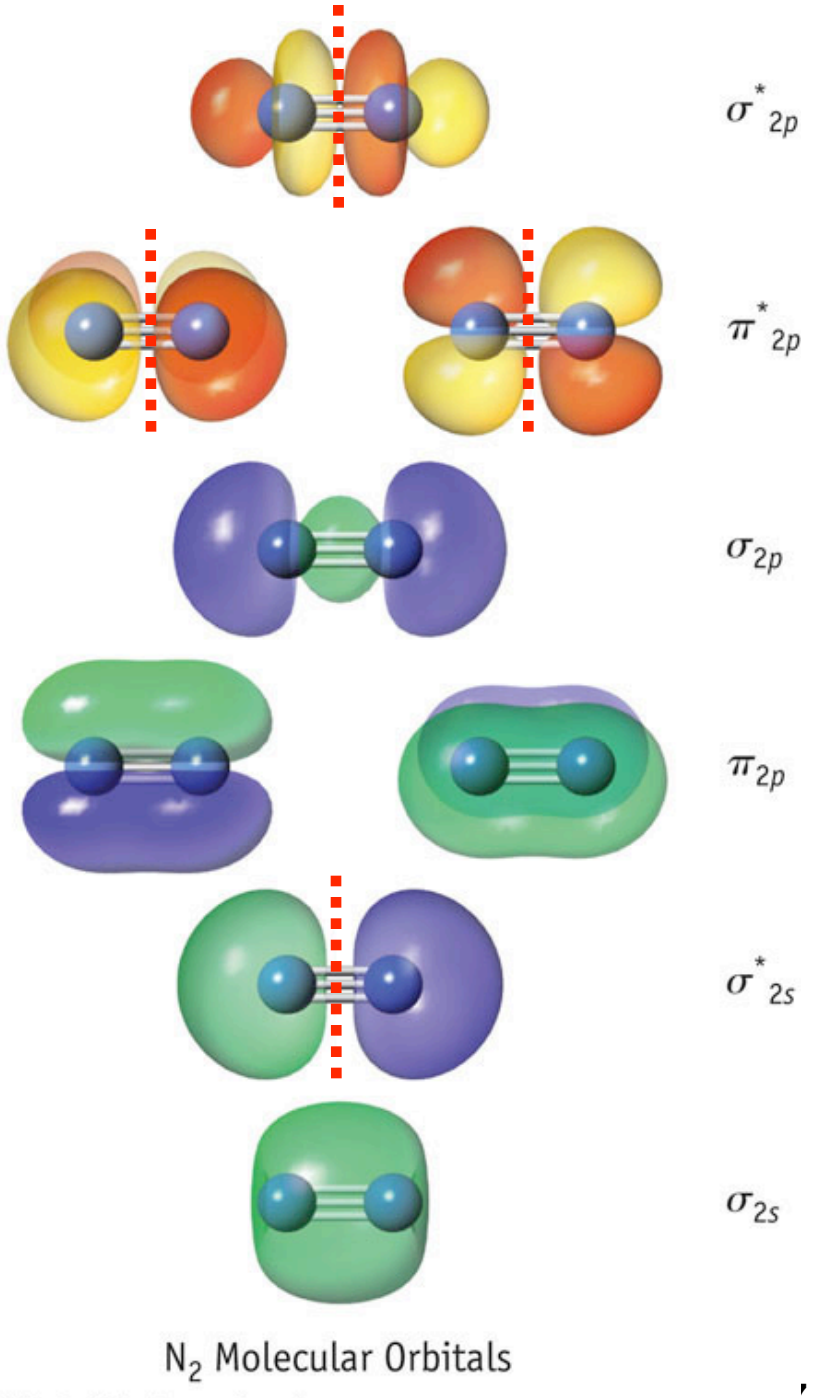
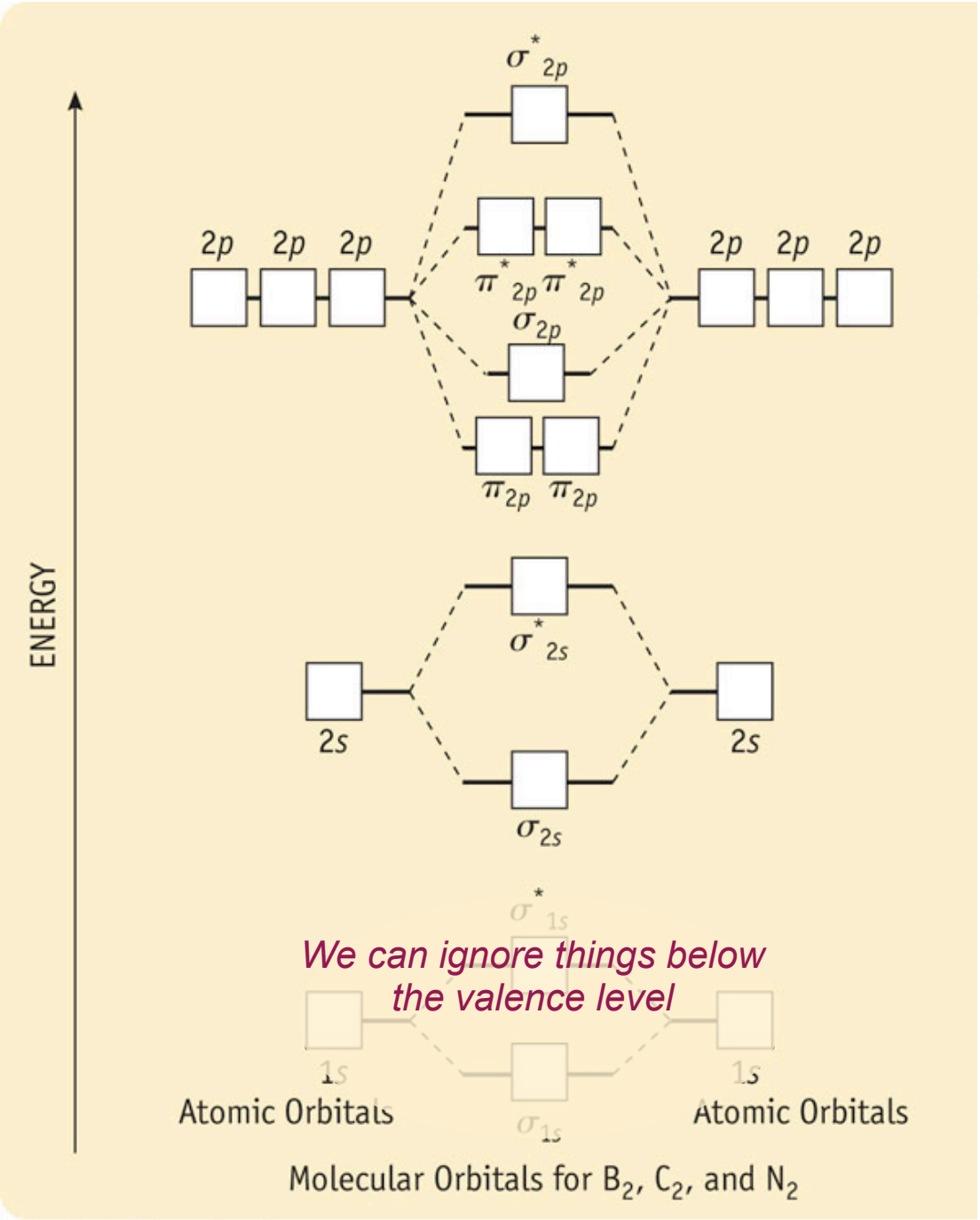


Molecular Orbitals for B_2, C_2, and N_2

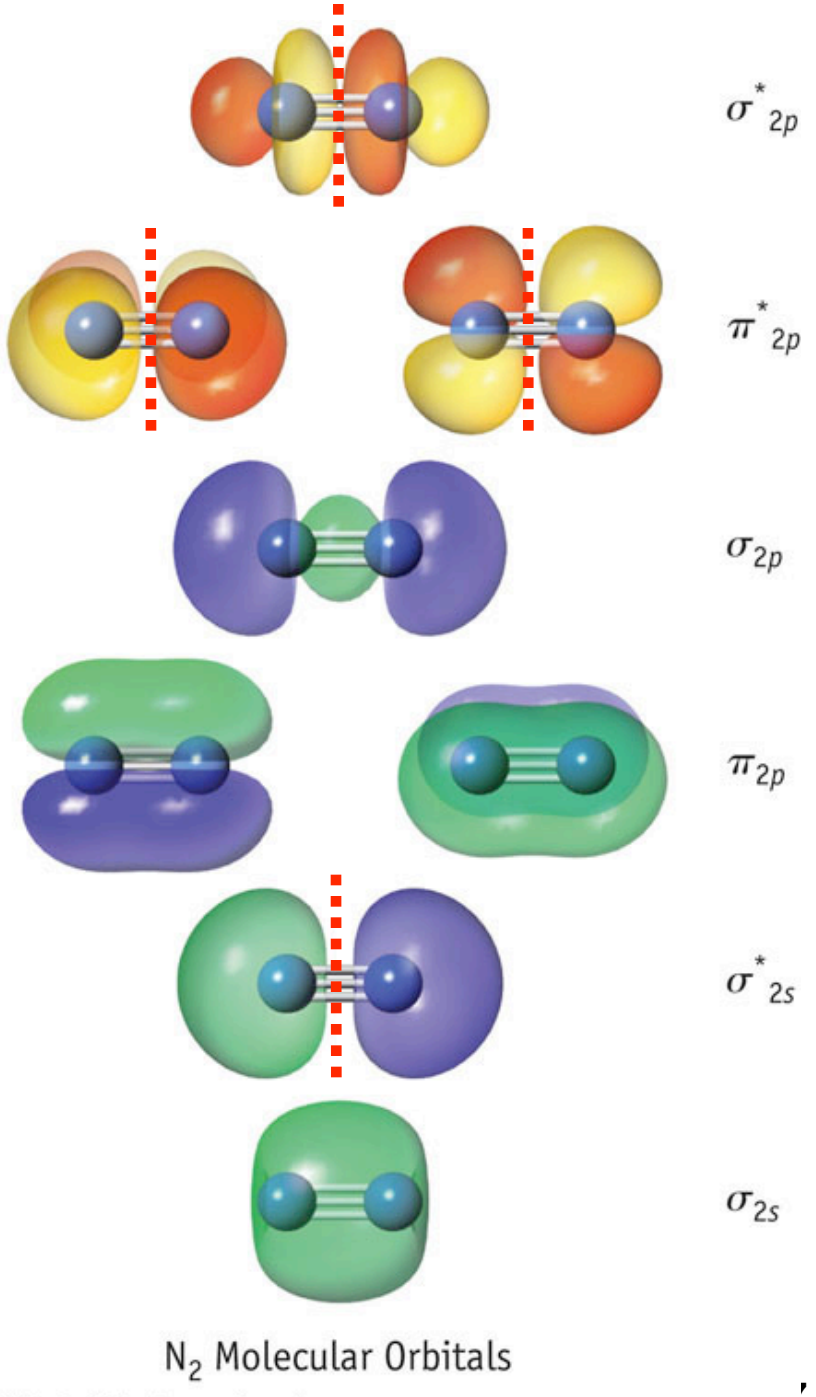


N_2 Molecular Orbitals



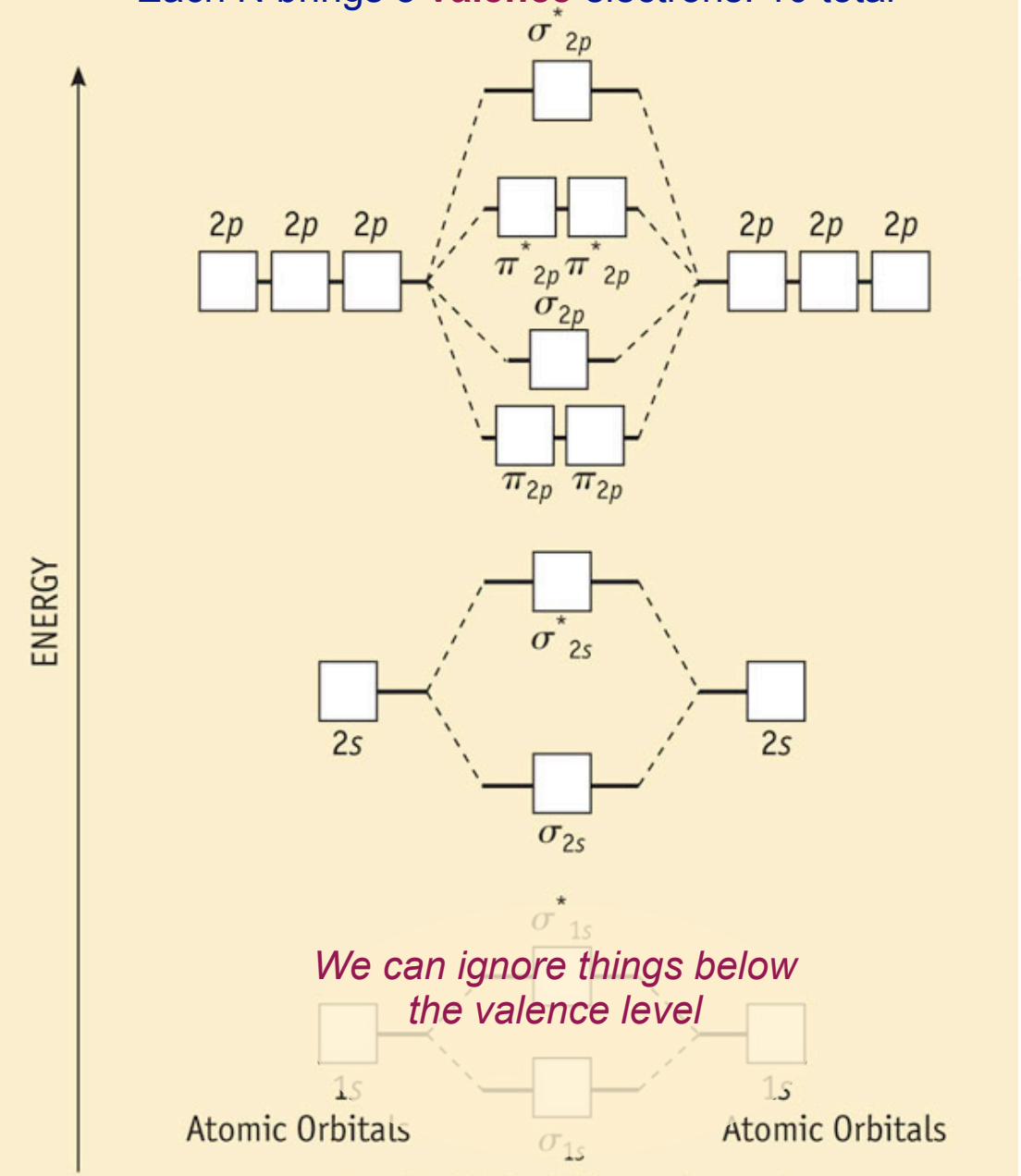
We can ignore things below the valence level

Molecular Orbitals for B_2, C_2, and N_2



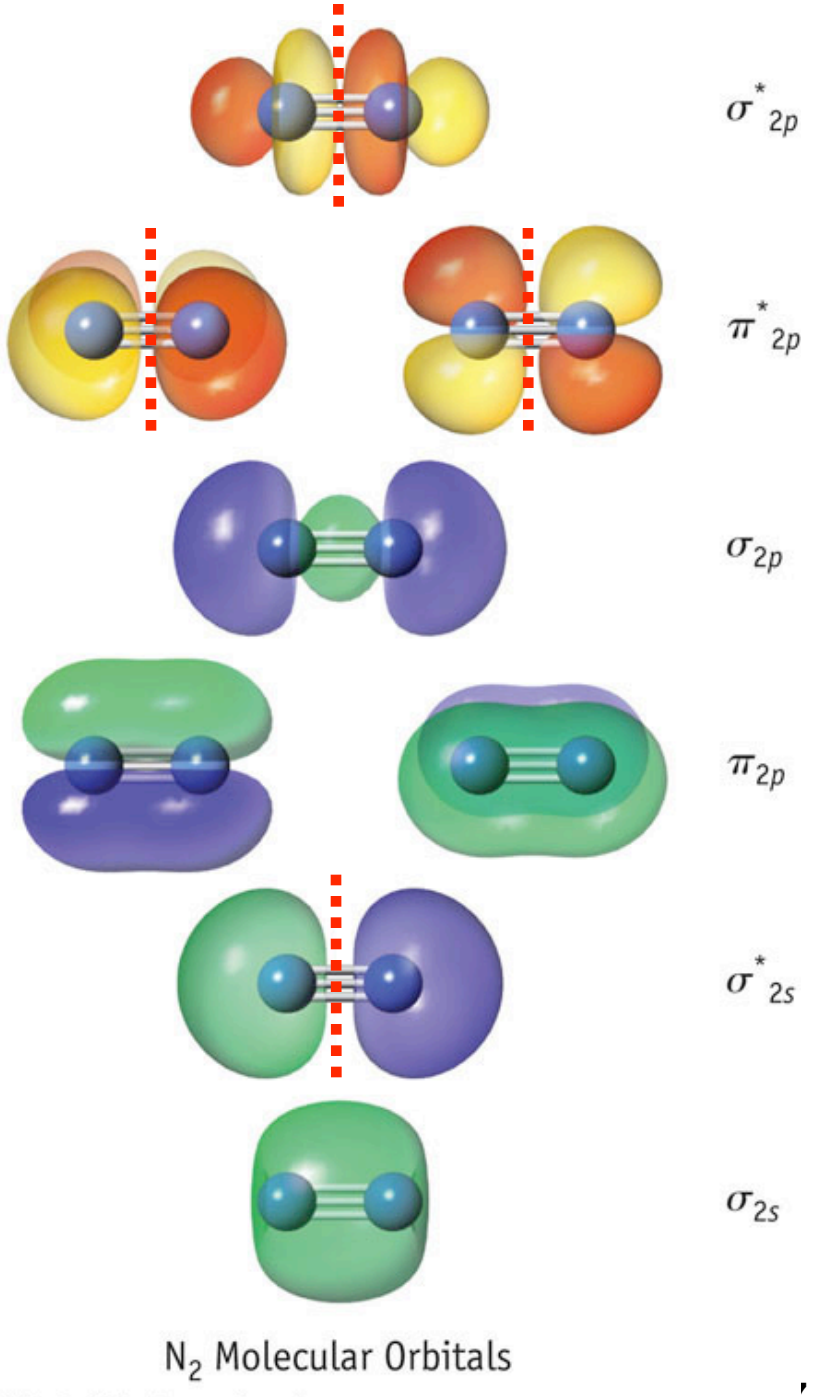
N_2 Molecular Orbitals

Each N brings 5 **valence** electrons: 10 total



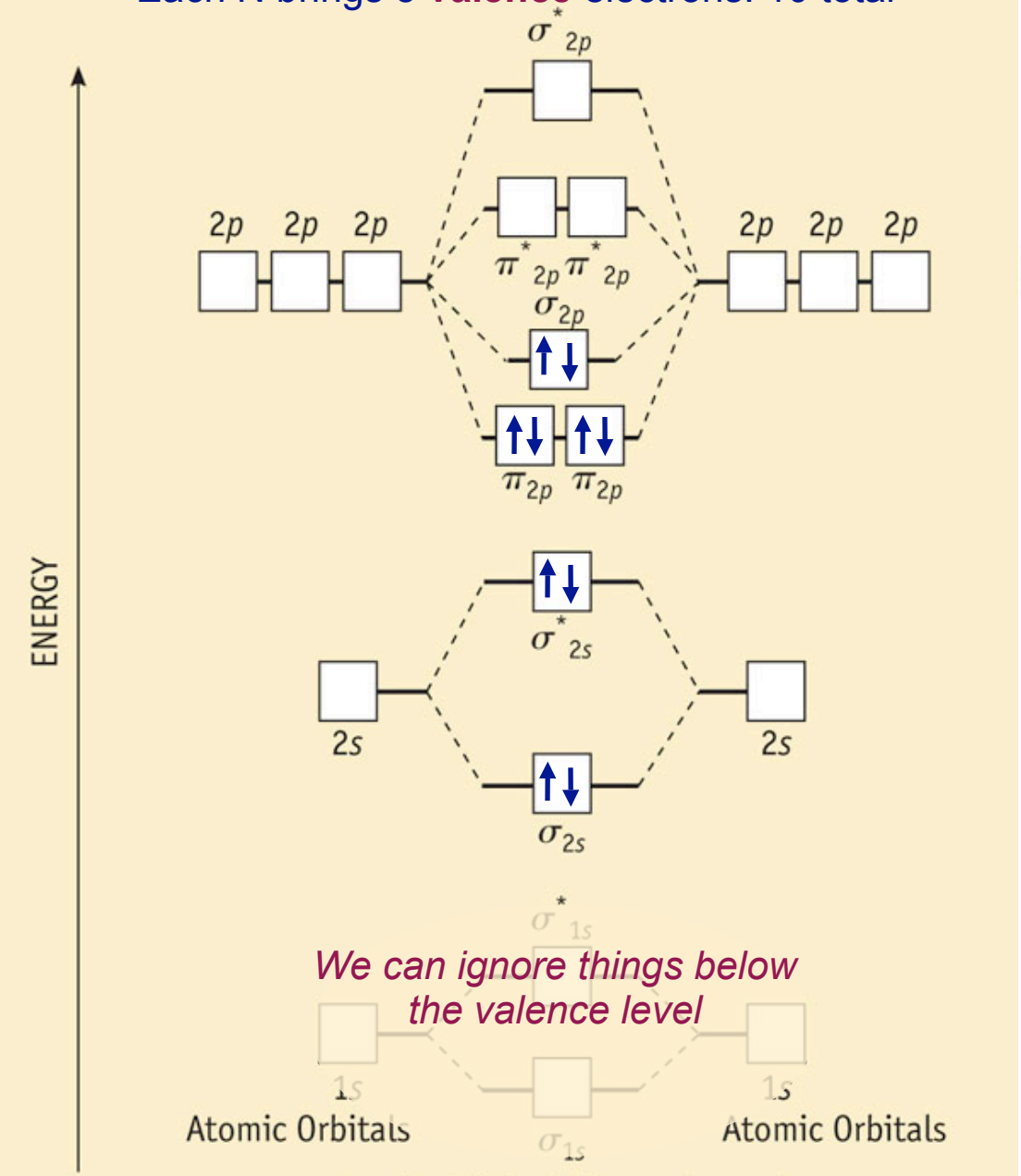
We can ignore things below the valence level

Molecular Orbitals for B_2, C_2, and N_2



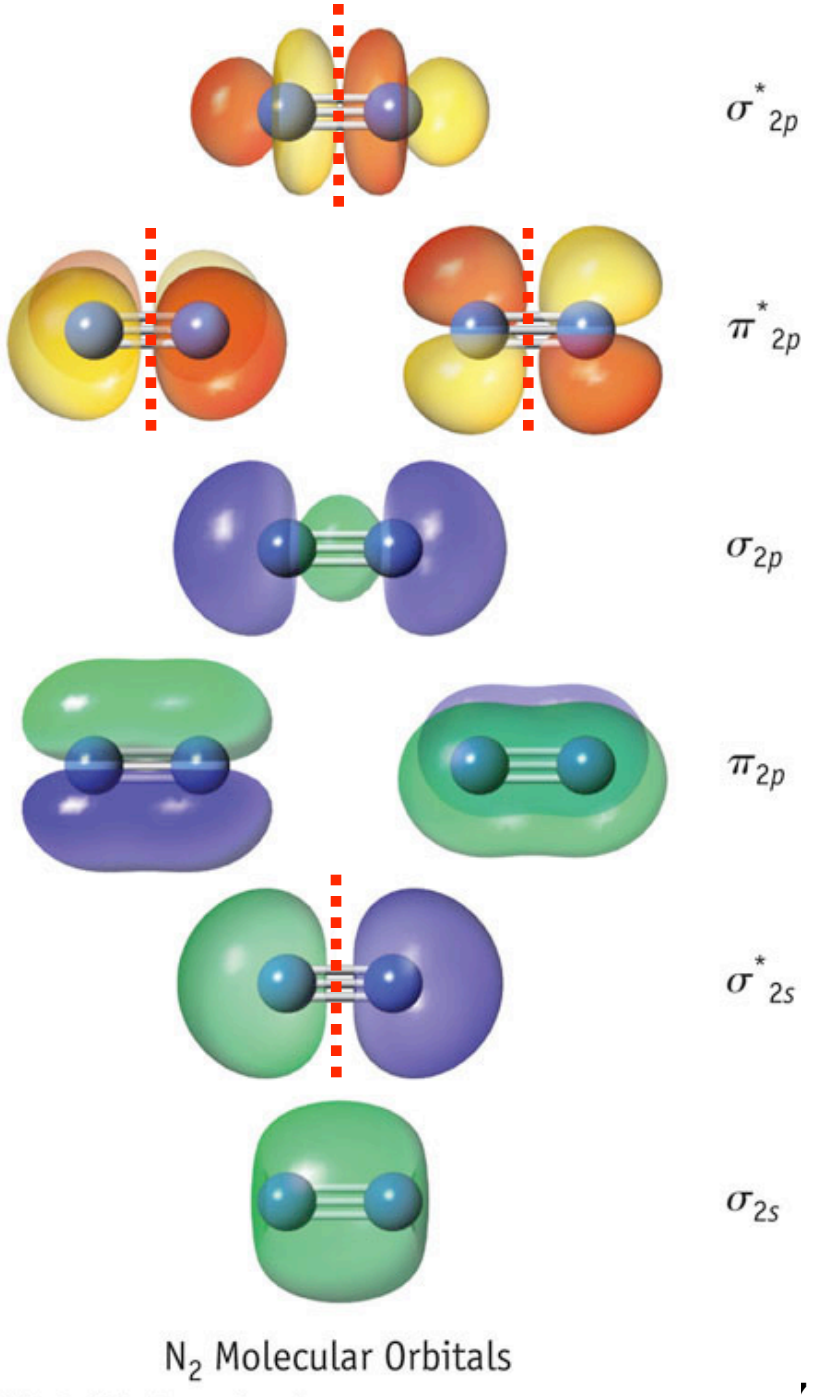
N_2 Molecular Orbitals

Each N brings 5 **valence** electrons: 10 total



We can ignore things below the valence level

Molecular Orbitals for B_2, C_2, and N_2

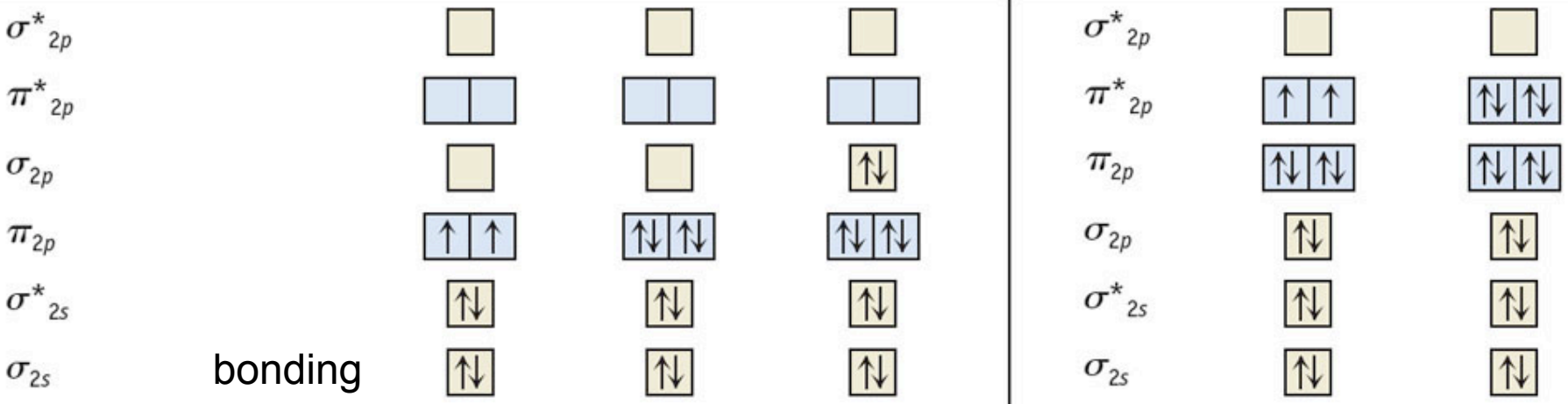


N_2 Molecular Orbitals

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear Diatomic Molecules of Second-Period Elements

	B_2	C_2	N_2	O_2	F_2
σ^*_{2p}	☐	☐	☐	☐	☐
π^*_{2p}	☐☐	☐☐	☐☐	↑☐↑	↑↓☐↑↓
σ_{2p}	☐	☐	↑↓	↑↓↑↓	↑↓↑↓
π_{2p}	↑↑	↑↓↑↓	↑↓↑↓	↑↓	↑↓
σ^*_{2s}	↑↓	↑↓	↑↓	↑↓	↑↓
σ_{2s}	↑↓	↑↓	↑↓	↑↓	↑↓
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear Diatomic Molecules of Second-Period Elements



	B_2	C_2	N_2	O_2	F_2
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TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear Diatomic Molecules of Second-Period Elements

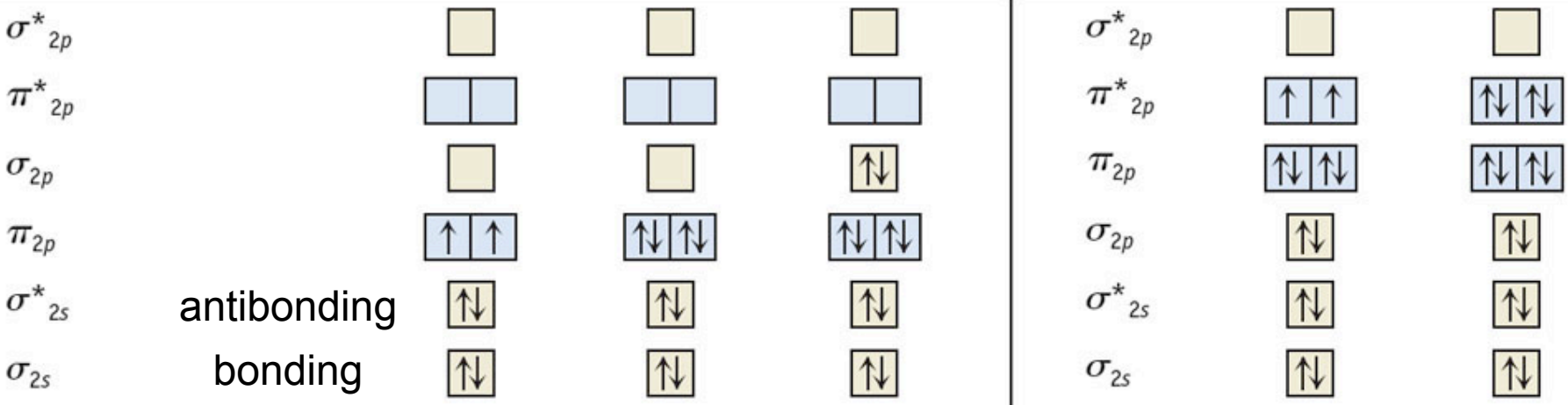

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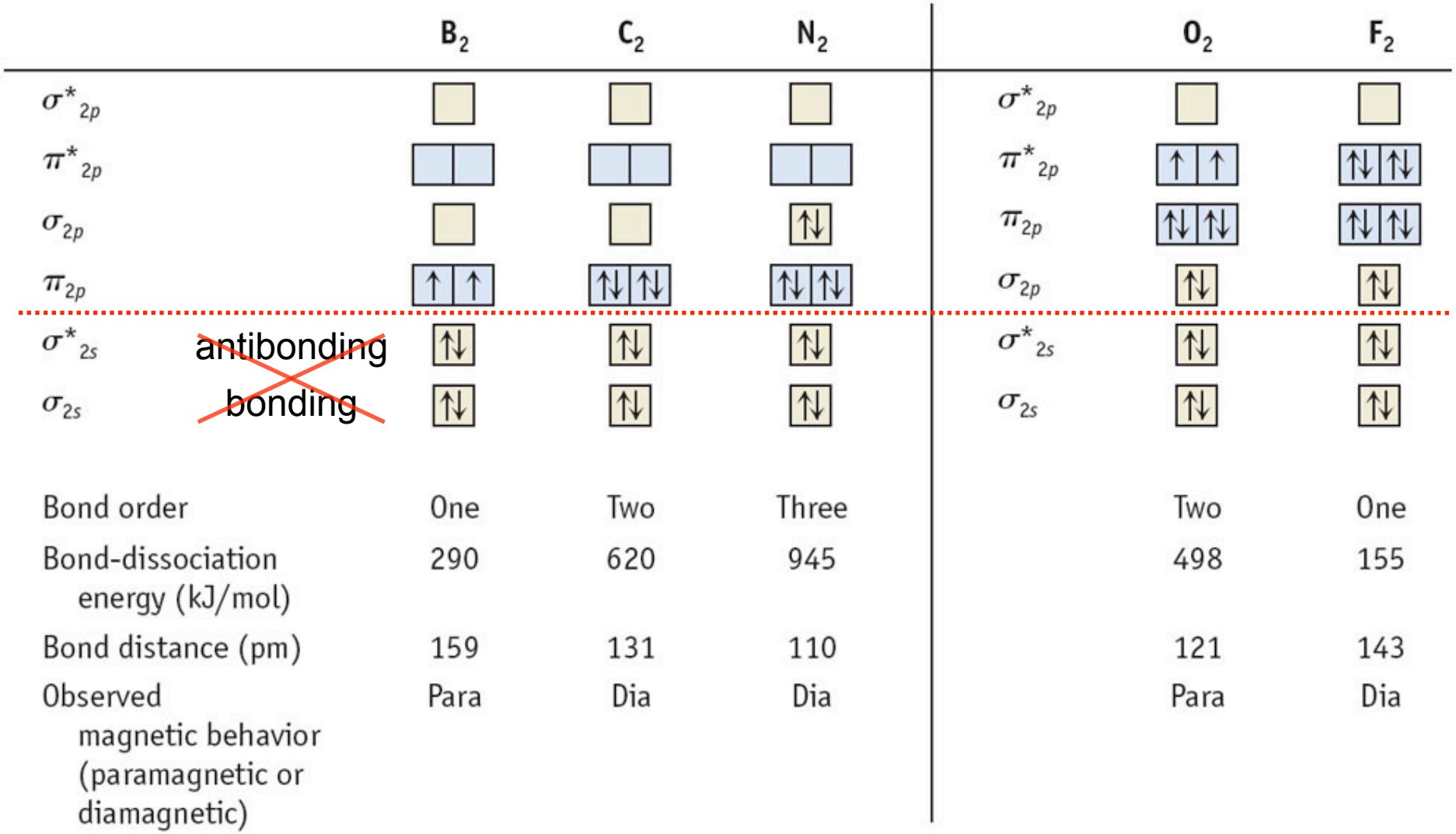
TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear Diatomic Molecules of Second-Period Elements



	B_2	C_2	N_2	O_2	F_2
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Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear

1 bond

	B_2	C_2	N_2	O_2	F_2
σ^*_{2p}					
π^*_{2p}					
σ_{2p}					
π_{2p}					
σ^*_{2s}					
σ_{2s}					
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

~~antibonding~~ ~~bonding~~

Table 9-1, p. 428

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear

1 bond 2 bonds

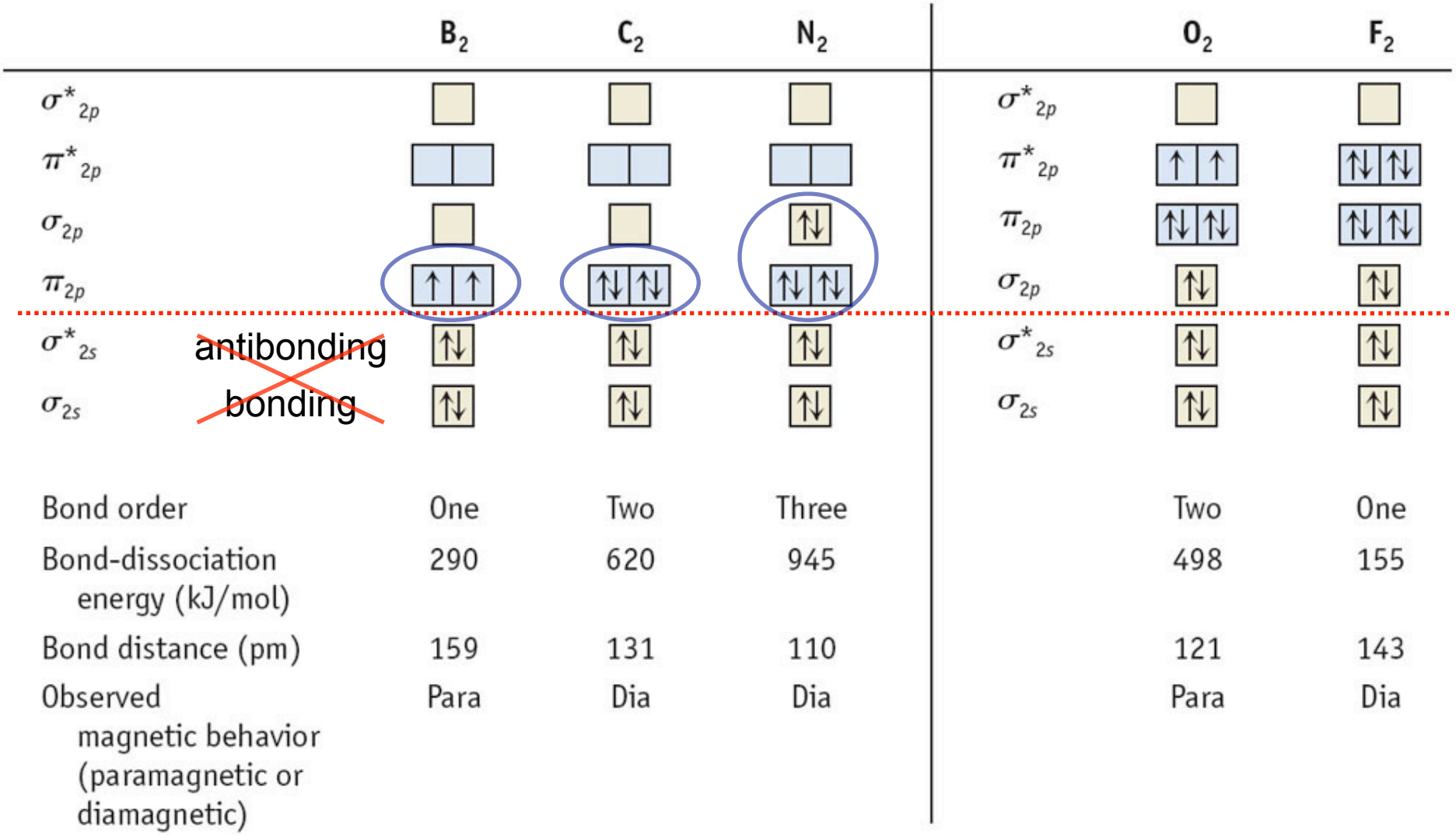
	B_2	C_2	N_2	O_2	F_2
σ^*_{2p}	☐	☐	☐	☐	☐
π^*_{2p}	☐☐	☐☐	☐☐	↑↑	↑↓↑↓
σ_{2p}	☐	☐	↑↓	↑↓↑↓	↑↓↑↓
π_{2p}	↑↑	↑↓↑↓	↑↓↑↓	↑↓	↑↓
σ^*_{2s}	↑↓	↑↓	↑↓	↑↓	↑↓
σ_{2s}	↑↓	↑↓	↑↓	↑↓	↑↓
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

~~antibonding~~ ~~bonding~~

Table 9-1, p. 428

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear

1 bond 2 bonds 3 bonds

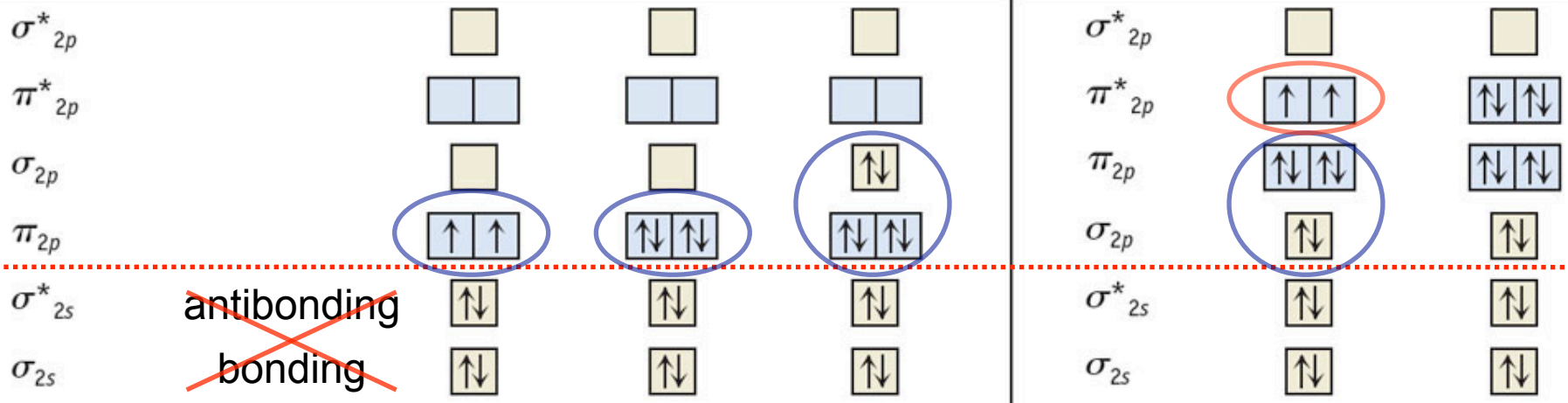


	B_2	C_2	N_2	O_2	F_2
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

Table 9-1, p. 428

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear

1 bond 2 bonds 3 bonds 3-1=2

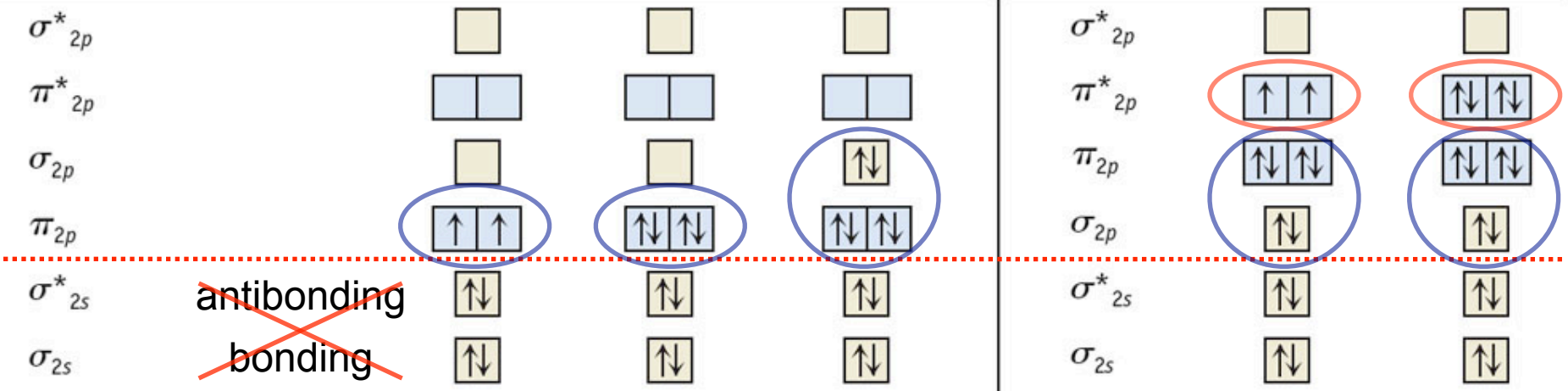


	B_2	C_2	N_2	O_2	F_2
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

Table 9-1, p. 428

TABLE 9.1 Molecular Orbital Occupations and Physical Data for Homonuclear

1 bond 2 bonds 3 bonds 3-1=2 3-2=1



	B_2	C_2	N_2	O_2	F_2
Bond order	One	Two	Three	Two	One
Bond-dissociation energy (kJ/mol)	290	620	945	498	155
Bond distance (pm)	159	131	110	121	143
Observed magnetic behavior (paramagnetic or diamagnetic)	Para	Dia	Dia	Para	Dia

Table 9-1, p. 428