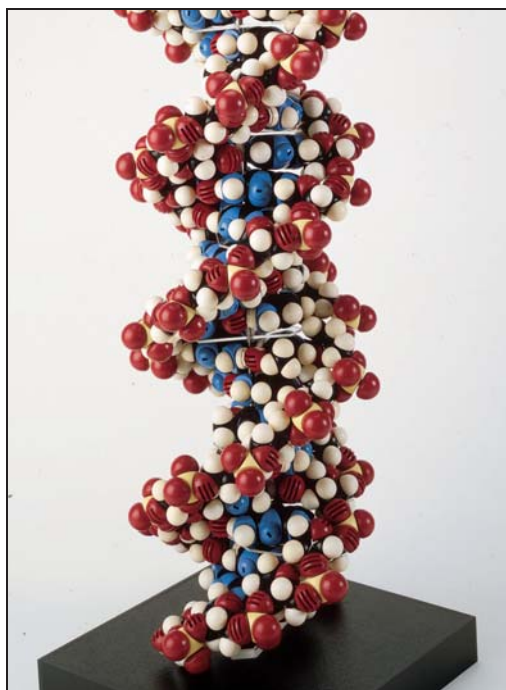


CPK Atomic Models



Nucleic Acid Helices, see page P13



Teaching Sets, see pages P14 - P15



Assembled Models, see pages P16 - P17



Assembled Models, see pages P16 - P17

- **How CPK Models are Sold**.....see page P2
- **Specifications and Assembly**.....see page P3
- **Connector Links**.....see page P4
- **Accessories**.....see page P5
- **Carbon Atoms**.....see pages P6 - P7
- **Oxygen Atoms**.....see page P8
- **Nitrogen Atoms**.....see page P9
- **Halogen Atoms**.....see page P10
- **Hydrogen, Phosphorus & Sulphur Atoms**.....see page P11
- **Metal Atoms & Amine Cap**.....see page P12
- **Nucleic Acid Helices & Components**.....see page P13
- **Teaching Sets**.....see pages P14 - P15
- **Assembled Models**.....see pages P16 - P17

Harvard Apparatus CPK[®] Atomic Models are sold three ways:

1. Individual Atomic Models, Connectors, and Accessories
These are specified on the following pages.

2. Sets for Specific Purposes

3. Assembled Molecular Structures

It is often more convenient to buy pre-assembled molecular structures. There is a large selection of these on the following pages.

Harvard Apparatus is always ready to quote for the custom assembly of all types of molecular structures.



Specifications and Assembly

Scale

1.25 cm/Å. Large enough to maintain high accuracy, yet small enough so that macromolecules are not unwieldy. For example, a model 20 x 40 x 100 Å can be built on a table top.

Accuracy

Bond Angles $\pm 0^\circ 30'$; Covalent radii $\pm 0.01\text{\AA}$; van der Waals radii $\pm 0.03\text{\AA}$. These are as they occur in most biomolecular structures, and these data agree generally with those published by Corey & Pauling. However, several changes reflecting recent observations have been incorporated.

Density

Less than 1.0 gram/ml for a molecule as a whole. For maximum strength with minimum weight, the atoms are hollow. Except for hydrogen, they are injection-molded in Implex, a hard and durable modified acrylic polyester. Hydrogen has an elastically-compressible polyethylene shell.

Color

Atoms and connectors are easily identified since each component is color-coded. The color cannot be worn away since it is an integral part of the plastic. Further, atom surfaces are satin-finished so that they can be lighted easily for vivid photography to illustrate journal articles.

Restricted Rotation

The rotation of certain atoms may be prevented with a special keyed link, see BS4 67-7039 Connector Link, Locking on following page. The rotation of tetrahedral carbons in C-C bonds may be hindered with a special carbon link to produce the three-fold rotational potential characteristic of such bonds, see BS4 67-7047 Connector Link, Carbon on following page.

Hydrogen Bonding

Linear and non-linear bonded hydrogen species provide functional H-bonds to the appropriate species of nitrogen and oxygen. H-bond distance is adjustable.

Special Atom Species

A user may construct additional atom species not offered as regular CPK Atomic Models and use them with the regular CPK Atomic Models by attaching the BS4 67-7088 Socket. This Socket takes all seven of the connector links offered on the following page.



Assembling or Taking Apart CPK[®] Atomic Models is Easy:

Assembly

A Connector Link is placed in the well on the end of the handle of the BS4 67-7120 Construction Tool. The Connector Link is then pressed into the female socket of the atom. The second atom is simply pressed onto the first with a slight twist, and the bond is made.

Taking Apart

To remove a Connector Link, the forked end of the BS4 67-7120 Construction Tool is slipped around the center groove of the link, and the tool is pried upward.

The atoms are held together with great tenacity. A force of 5 to 7 kg is required to separate them. This force is readily furnished by the levering blade of the BS4 67-7120 Construction Tool.

Connector Links

Connector Links

The marked superiority of the CPK® Atomic Models derives largely from Dr. Koltun's Connector Links. His analysis of the engineering problems involved led him to combine new plastic materials with innovative link designs which satisfy four critical requirements simultaneously:

- Hold atoms together with great tenacity. A force of 5 to 7 kg is required to separate them. This force is readily furnished by the levering blade of the BS4 67-7120 Construction Tool, see page P5
- Permit distortions of bond angles to vary up to $\pm 8^\circ$ with negligible loss in bond strength.
- Develop sufficient rotational friction to assure that large, extended side chains, often attached by a single bond, will remain indefinitely in proper steric orientation.
- Allow bond distances to be shortened or lengthened. The connectors are made of Texin, a hard, rubber-like elastomer which is strong but resilient and flexible.

Since bond distances and angles for particular atoms are known to vary even in similar structures, two special links, in addition to the standard link, are provided to increase or decrease the normal bond distance by $+0.08\text{\AA}$ or -0.05\AA .

A special 'gluing' link is also available for permanently connecting atoms at standard bond distances.

The various link types are color-coded to aid identification.



Connector Link, Locking

Provides standard bond distance and has locking splines that mate with keyways in the female socket of the atoms to prevent rotation. Gray.

Catalog No.	\$	Product
BS4 67-7039		Connector Link, Locking



Connector Link, Carbon

Provides standard bond distance. Has locking splines at each end placed 180° out of phase that restrict rotation of BS4 67-6577 Carbon, Tetrahedral. Black.

Catalog No.	\$	Product
BS4 67-7047		Connector Link, Carbon



Connector Link, Standard

Provides standard bond distance. Off-white.

Catalog No.	\$	Product
BS4 67-7005		Connector Link, Standard



Connector Link, Long

Lengthens bond distance by 0.08\AA . Red.

Catalog No.	\$	Product
BS4 67-7021		Connector Link, Long



Connector Link, Bayonet H-Bond Replacement

This is the connector that is supplied with the BS4 67-6684 H-Bond, Bayonet Type, Hydrogen atom. It is for replacement if the tip of the connector supplied with the atom breaks. Off-white.

Catalog No.	\$	Product
BS4 67-7062		Connector Link, Bayonet H-Bond Replacement



Connector Link, Short

Shortens bond distance by 0.05\AA . Blue.

Catalog No.	\$	Product
BS4 67-7013		Connector Link, Short



Connector Link, Gluing

For constructing permanent structures at standard bond distance using trichloroethylene 'glue' or Testor's® Polystyrene Cement. Black.

Catalog No.	\$	Product
BS4 67-7054		Connector Link, Gluing



Socket

Standard female socket to be mounted on special atom species fabricated by the user. This socket takes all of the Connector Links listed on page P4. White.

Catalog No.	\$	Product
BS4 67-7088		Socket



Screw for Amine Cap

This screw is used to connect the BS4 67-7112 Amine Cap, see page P12, to the BS4 67-6726 Hydrogen H-Bond, Hook Type when the hook is removed.

Catalog No.	\$	Product
BS4 67-7187		Amine Cap Screw



H-Bond Spacer

For use with the BS4 67-6726 Hydrogen H-Bond, Hook Type, see page P11. One or more of these spacers can be put on over the hook of the BS4 67-6726 to increase the bond distance by 0.2Å for each spacer used. White.

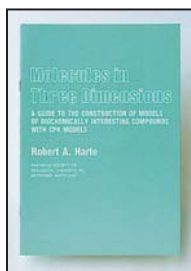
Catalog No.	\$	Product
BS4 67-7096		H-Bond Spacer



Metal Atom Connector Link

Supplied with self-tapping screw. For use with BS4 67-6999 Metal, All Purpose, see page P12. Note that two of these connectors are supplied with each BS4 67-6999 Metal, All Purpose. White.

Catalog No.	\$	Product
BS4 67-7161		Metal Atom Connector Link
BS4 67-7229		Single Metal Atom, No Connector Link



Pamphlet: "Molecules in Three Dimensions"

A 20-page pamphlet subtitled A Guide to the Construction of Models of Biochemically Interesting *Compounds with CPK Models*. Written by Robert A. Harte of the American Society for Biochemistry and Molecular Biology.

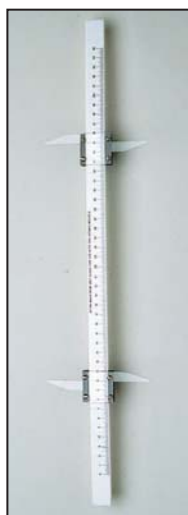
Catalog No.	\$	Product
BS4 67-7179		Molecules in 3 Dimensions



Hydrogen Wrench

This wrench is for use with the BS4 67-6726 Hydrogen H-Bond, Hook Type, see page P11. When the hook of that atom is placed in the slot of the BS4 67-6874 Oxygen, Single Bond or BS4 67-6916 Oxygen, Indented Double Bond atom, this wrench fits over the eight-sided face of the basic hydrogen body, and the body is turned until the hook is brought up securely against the oxygen atom.

Catalog No.	\$	Product
BS4 67-7138		Hydrogen Wrench



Angstrom Unit Scale Caliper

An Angstrom Unit Scale caliper calibrated at 1.25 cm/Å (the scale of the CPK models) which offers a convenient way to make direct measurements in Angstroms on CPK structures. Range 0 to 30Å graduated in 0.1Å with each Å numbered. Sturdy bar engraved with black-filled graduations. Accurate measurement is attained by two spring-loaded cursors with long transparent plastic jaws. One cursor is reversible to make internal and external measurements. Overall length 64 cm (25 in).

Catalog No.	\$	Product
BS4 67-7146		Angstrom Unit Scale Caliper



Construction Tool

To assemble the models, a Connector Link is placed in the well on the end of the handle of this Construction Tool. The Connector Link is then pressed into the female socket of the atom. The second atom is simply pressed onto the first with a slight twist, and the bond is made. To separate the atoms, the blade of the Construction Tool is merely inserted between the atoms to pry them apart. A Connector Link may be completely removed by slipping the forked end of the Construction Tool around the center groove of the link, and the tool is pried upward.

Catalog No.	\$	Product
BS4 67-7120		Construction Tool

Carbon Atoms

Atom Species	Catalog No.	Bond Arrangement	Color	Bond Angle	van der Waals Radii, Å	Covalent Radii, Å		
						Single Bond	Double Bond	Triple Bond
C-Acetylenic Triple Bond	BS4 67-6593 \$	$\text{—C}\equiv$	Black	180°	1.60	0.70	—	0.60
C-Aromatic-6	BS4 67-6569 \$	$\text{—C}\begin{smallmatrix} // \\ // \end{smallmatrix}$	Black	120°	1.70	0.73	0.69 (partial)	—
C-Aromatic-5	BS4 67-6551 \$	$\text{—C}\begin{smallmatrix} // \\ // \end{smallmatrix}$	Black	108° 126°	1.70	0.73	0.68 (partial)	—
C-Fused 5-5 Rings	BS4 67-6600 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}=\text{C}\begin{smallmatrix} // \\ // \end{smallmatrix}$	Black	$\begin{smallmatrix} \top 108^\circ \\ \top 108^\circ \\ \top 108^\circ \\ \top 108^\circ \end{smallmatrix}$	1.70 1.70	—	—	—
C-Ethylenic Double Bond	BS4 67-6585 \$	$\text{>C}=\text{}$	Black	125°15' 109°30'	1.60	0.73	0.67	—
C-Fused 6-6 Rings	BS4 67-6619 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}=\text{C}\begin{smallmatrix} // \\ // \end{smallmatrix}$	Black	$\begin{smallmatrix} \top 120^\circ \\ \top 120^\circ \\ \top 120^\circ \\ \top 120^\circ \end{smallmatrix}$	1.70 1.70	0.69	—	—
C-Tetrahedral	BS4 67-6577 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}$	Black	109°30'	—	0.77	—	—
C-Tetrahedral-4	BS4 67-6528 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}=\text{}$	Black	$\begin{smallmatrix} 114^\circ & 112^\circ \\ 114^\circ & 88^\circ \end{smallmatrix}$	1.25	$\begin{smallmatrix} 0.76 \\ 0.77 \end{smallmatrix}$	—	—
C-Fused 6-5 Rings	BS4 67-6601 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}=\text{C}\begin{smallmatrix} // \\ // \end{smallmatrix}$	Black	$\begin{smallmatrix} \top 120^\circ \\ \top 108^\circ \\ \top 120^\circ \\ \top 108^\circ \end{smallmatrix}$	1.70 1.70	—	—	—
C-Amine	BS4 67-6536 \$	$\text{>C}=\text{}$	Black	115° 125° 120°	1.50	0.72 0.75	0.67	—
C-Trigonal-4	BS4 67-6544 \$	$\begin{smallmatrix} // \\ // \end{smallmatrix}\text{C}$	Black	134° 92° 134°	1.48	0.73 0.73	0.65	—



Carbon, Acetylenic Triple Bond

Covalent radius 0.60Å along triple bond; this face marked 'C≡'; second socket notched to accept restricted rotation connectors. Covalent radius 0.70Å along single bond. Black.

Catalog No. \$ Product

BS4 67-6593 Carbon, Acetylenic Triple Bond



Carbon, Aromatic-5

For constructing unsaturated five-member rings such as BS4 67-8266 Imidazole, BS4 67-8272 Pyrazole, and C-8 carbon in BS4 67-8262 Purine. Covalent radius 0.68Å to atoms within ring and covalent radius 0.73Å to atoms outside ring; bond angle 108° between atoms within ring and 126° between single-bonded atom outside ring and double-bonded ring atoms; symbol '5' stamped on one inner face. Partial double bond sockets notched to accept restricted rotation connectors. Black. Same as BS4 67-6825 Nitrogen, Aromatic-5, listed on page P9 except for color.

Catalog No. \$ Product

BS4 67-6551 Carbon, Aromatic-5



Carbon, Aromatic-6

For constructing six-membered rings such as BS4 67-8250 Benzene, BS4 67-8255 Pyridine and BS4 67-8263 Pyrimidine. Covalent radius 0.69Å within ring and covalent radius 0.73Å to single atoms outside ring; symbol '6' stamped on one inner face. Partial double bond sockets are notched to accept restricted rotation connectors. Black.

Catalog No. \$ Product

BS4 67-6569 Carbon, Aromatic-6

Carbon Atoms



Carbon, Special for Fused 5-5 Rings

A special double-atom unit representing carbon atoms common to both rings. The 108° face bonds in the two five-member rings, e.g. pentalenes. Black.

Catalog No.	\$	Product
BS4 67-6600		Carbon, Special for Fused 5-5 Rings



Carbon, Ethylenic Double Bond

Covalent radius 0.67Å along the double bond; this face marked 'C=' and connector socket is notched to accept restricted rotation connectors; covalent radius 0.73Å along single bonds; bond angle 125°15' between the double and single bonds; bond angle 109°30' between single bonds. Black.

Catalog No.	\$	Product
BS4 67-6585		Carbon, Ethylenic Double Bond



Carbon, Special for Fused 6-6 Rings

A special double-atom unit representing the carbons common to fused 6-membered unsaturated rings, e.g., BS4 67-8252 Anthracene, BS4 67-8253 Phenanthrene, BS4 67-8251 Naphthalene. The unit is stamped '6-6' for identification. Covalent radius 0.69Å with a bond angle of 120°. Black.

Catalog No.	\$	Product
BS4 67-6619		Carbon, Special for Fused 6-6 Rings



Carbon, Trigonal-4

For constructing four-membered rings. Intraring covalent radii 0.73Å stamped on one face. A permanent connector molded into the other intraring surface provides the same bond length as the BS4 67-7005 Connector Link, Standard, see page P4. Exocyclic face is stamped with the covalent radius 0.65Å. Angle between two intraring bond axes is 92°; bond angle 134° between the intraring bond axis and the axis of the atom outside the ring. Black.

Catalog No.	\$	Product
BS4 67-6544		Carbon, Trigonal-4



Carbon, Tetrahedral

Connector sockets triple-notched for simulation of restricted rotational potential. For special connector link, see BS4 67-7047 Connector Link, Carbon on page P4. Covalent radius 0.77Å; bond angle 109°30'. Black.

Catalog No.	\$	Product
BS4 67-6577		Carbon, Tetrahedral



Carbon, Tetrahedral-4

For constructing four-membered ring structures such as b-lactams, BS4 67-0400 Cyclobutane and methylene cyclobutane. Covalent radii 0.77Å to atoms within the ring and 0.76Å to atoms outside the ring. Each face of the atom is marked with the appropriate covalent radius. Intraring bond angle is 88°. Black.

Catalog No.	\$	Product
BS4 67-6528		Carbon, Tetrahedral-4



Carbon, Special for Fused 6-5 Rings

A special double-atom unit representing the carbons common to both rings. The 120° face bonds in the six-member ring; the 108° face bonds in the five-member ring, e.g., BS4 67-8262 Purine and BS4 67-8291 Indole. Black.

Catalog No.	\$	Product
BS4 67-6601		Carbon, Special for Fused 5-6 Rings



Carbon, Amine

Covalent radii stamped on each face of this atom as follows: 0.72Å to amide nitrogen, 0.67Å to oxygen, 0.75Å to chain carbon; bond angle 115° between amide nitrogen and chain carbon; bond angle 120° between oxygen and chain carbon; bond angle 125° between oxygen and amide nitrogen; also used for general planar carbon, e.g., carboxylate carbon. Sockets notched to accept restricted rotation connectors. Black.

Catalog No.	\$	Product
BS4 67-6536		Carbon, Amine

Oxygen Atoms and Nitrogen Atoms

Oxygen Atoms					Covalent Radii, Å			
Atom Species	Catalog No.	Bond Arrangement	Color	Bond Angle	van der Waals Radii, Å	Single Bond	Double Bond	Triple Bond
O-Single Bond	BS4 67-6874	--O<	Red	110°	1.35	0.66	–	–
O-Double Bond	BS4 67-6890	=O	Red	–	1.35	–	0.57	–
O-Indented Double Bond	BS4 67-6916	--O==	Red	–	1.35	–	0.57	–
Nitrogen Atoms								
N-Nitrile Triple Bond	BS4 67-6792	–N≡	Blue	180°	1.60	0.70	–	0.60
N-Aromatic-5*	BS4 67-6825	–N≡	Blue	108° 126°	1.70	0.73	0.68 (partial)	–
N-Amide*	BS4 67-6791	>N=	Blue	123° 114° 123°	1.45	0.70 0.70	0.60 (partial)	–
N-Aromatic-6*	BS4 67-6833	–N≡	Blue	120°	1.70	0.73	0.69 (partial)	–
N-Tetrahedral*	BS4 67-6841	N	Blue	109°30'	–	0.70	–	–
N-Tetrahedral-4	BS4 67-6858	N	Blue	114° 112° 114° 88°	1.25	0.76 0.77	–	–
N-Trigonal-4	BS4 67-6866	N	Blue	134° 92° 134°	1.48	0.73 0.73	0.65	–

* For nitrogen conversion, see BS4 67-7112 Amine Cap on page P12.

Oxygen, Single Bond

Triple-slotted to accept BS4 67-6684 H-Bond, Bayonet Type, Hydrogen and BS4 67-6726 H-Bond, Hook Type, Hydrogen for H-bonding. Center slot extends $\pm 48^\circ$; side slots $\pm 35^\circ$ at $\pm 15^\circ$ displacement from center line; Covalent radius 0.66Å; bond angle 110°. Red.

Catalog No.	\$	Product
BS4 67-6874		Oxygen, Single Bond

Oxygen, Double Bond

Also serves as negatively-charged oxygen. Covalent radius 0.57Å. Red.

Catalog No.	\$	Product
BS4 67-6890		Oxygen, Double Bond

Oxygen, Indented Double Bond

With indented sides; indentations on radii of 1.15Å about centers spaced laterally, 2.1Å from spherical center of atom. Three slots on the surface of the atom and parallel to the long axis of the indentations accept BS4 67-6684 H-Bond, Bayonet Type, Hydrogen and BS4 67-6726 H-Bond, Hook Type, Hydrogen for H-bonding. All three slots extend $+48^\circ$ and the side slots are displaced $+15^\circ$ from the center line. Connector socket is notched to accept restricted rotation connectors. Covalent radius 0.57Å. Red.

Catalog No.	\$	Product
BS4 67-6916		Oxygen, Indented Double Bond

Nitrogen Atoms



Nitrogen, Nitrile Triple Bond

Covalent radius 0.60Å along triple bond; this face marked 'C≡' for triple bonding with BS4 67-6593 Carbon, Acetylenic Triple Bond to form nitriles or 'cyano' compounds; second socket notched to accept restricted rotation connectors. Covalent radius 0.70Å along single bond. Blue.

Catalog No.	\$	Product
BS4 67-6792		Nitrogen, Nitrile Triple Bond



Nitrogen, Aromatic-5

For use in five-membered rings such as in BS4 67-8266 Imidazole or in positions 7 and 9 in BS4 67-8262 Purine. Covalent radius 0.68Å to atoms within ring and covalent radius 0.73Å to atoms outside ring; bond angle 108° between atoms within ring and 126° between single-bonded atom outside ring and double-bonded ring atoms; symbol '5' stamped on one inner face. Partial double-bond sockets notched. BS4 67-7112 Amine Cap converts BS4 67-6825 Nitrogen, Aromatic-5 to azo nitrogen. For details of the BS4 67-7112 Amine Cap see page P12. Blue.

Catalog No.	\$	Product
BS4 67-6825		Nitrogen, Aromatic-5



Nitrogen, Amide

Covalent radii stamped on each face of this atom as follows: 0.60Å to amine carbon, 0.70Å to hydrogen bond hydrogen; 0.70Å to chain carbon. Bond angle 123° between amine carbon and H-bond hydrogen; 114° between chain carbon and H-bond hydrogen. One face has an 'H' stamped to facilitate construction of transpeptide linkages. Also used for general planar trigonal nitrogen as in NO₂ and with the BS4 67-7112 Amine Cap as azo nitrogen. For details of the BS4 67-7112 Amine Cap see page P12. Blue.

Catalog No.	\$	Product
BS4 67-6791		Nitrogen, Amide



Nitrogen, Aromatic-6

For use in six-membered rings such as BS4 67-8255 Pyridine and BS4 67-8263 Pyrimidine. Covalent radius 0.69Å within ring and covalent radius 0.73Å to single atoms outside ring; symbol '6' stamped on one inner face. Partial double-bond sockets notched to accept restricted rotation connectors. BS4 67-7112 Amine Cap, see page P12, converts BS4 67-6833 Nitrogen, Aromatic-6 to azo nitrogen. Blue.

Catalog No.	\$	Product
BS4 67-6833		Nitrogen, Aromatic-6



Nitrogen, Tetrahedral

Connector sockets notched for simulation of restricted rotational potential. Covalent radius 0.70Å; bond angle 109°30'. BS4 67-7112 Amine Cap, see page P12, converts BS4 67-6841 Nitrogen, Tetrahedral to amino nitrogen. Blue.

Catalog No.	\$	Product
BS4 67-6841		Nitrogen, Tetrahedral



Nitrogen, Tetrahedral-4

For constructing four-membered rings. Identical to BS4 67-6528 Carbon, Tetrahedral-4, see page P7, except for color. With BS4 67-7112 Amine Cap, see page P12, it is converted to a trivalent nitrogen for use in certain structures such as b-lactam ring in penicillin. Blue.

Catalog No.	\$	Product
BS4 67-6858		Nitrogen, Tetrahedral-4





Nitrogen, Trigonal-4

For constructing four-membered rings. Identical to BS4 67-6544 Carbon, Trigonal-4, see page P7, except for color. For constructing models such as free b-lactam and the four-membered ring in Δ²cephalosporins. Blue.

Catalog No.	\$	Product
BS4 67-6866		Nitrogen, Trigonal-4

Individual Atoms

Halogen Atoms, Hydrogen Atoms, Phosphorus and Sulfur

Halogen Atoms					Covalent Radii, Å			
Atom Species	Catalog No.	Bond Arrangement	Color	Bond Angle	van der Waals Radii, Å	Single Bond	Double Bond	Triple Bond
Bromide	BS4 67-6510 \$	—Br	Brown	—	1.95	1.14	—	—
Chloride	BS4 67-6650 \$	—Cl	Green	—	1.80	0.99	—	—
Fluoride	BS4 67-6676 \$	—F	Pale Green	—	1.35	0.57	—	—
Iodide	BS4 67-6734 \$	—I	Violet	—	2.15	1.35	—	—
Hydrogen Atoms								
Hydrogen	BS4 67-6692 \$	—H	White	—	1.00	0.33	—	—
H-Bond Hook Type	BS4 67-6726 \$	—H—	White	—	1.00	0.33	—	—
H-Bond Bayonet Type	BS4 67-6684 \$	—H—	White	—	1.00	0.33	—	—
Phosphorus and Sulfur Atoms								
Phosphorus Tetrahedral	BS4 67-6924 \$		Pale Yellow	109°30'	—	0.96	—	—
Sulfur Tetrahedral	— see BS4 67-6924	—	—	1.70	—	—	—	—
Sulfur Digonal	BS4 67-6957 \$		Yellow	104°	—	1.04	—	—



Bromide

'Br' stamped near socket. Covalent radius 1.14Å along single bond. Brown.

Catalog No. \$ **Product**
BS4 67-6510 Bromide



Fluoride

Covalent radius 0.57Å along single bond. Pale Green.

Catalog No. \$ **Product**
BS4 67-6676 Fluoride



Chloride

'Cl' stamped near socket. Covalent radius 0.99Å along single bond. Green.

Catalog No. \$ **Product**
BS4 67-6650 Chloride



Iodide

'I' stamped near socket. Covalent radius 1.35Å along single bond. Violet.

Catalog No. \$ **Product**
BS4 67-6734 Iodide

Hydrogen, Phosphorus, and Sulfur Atoms

Hydrogen



Hydrogen

Single bond; shell is elastically-compressible; a connector link is incorporated. White.

Catalog No.	\$	Product
BS4 67-6692		Hydrogen



Hydrogen H-Bond, Hook Type

Indentation radius 1.35Å about a center 1.66Å from spherical center of hydrogen atom. This hook-type hydrogen is designed to add substantial structural strength to the CPK hydrogen bonding system. White.

To connect the BS4 67-7112 Amine Cap, see following page, to the hydrogen body of the BS4 67-6726 Hydrogen H-Bond, Hook Type:

- (1) Unscrew and remove the metalhook from the hydrogen body.
- (2) The BS4 67-7112 Amine Cap has a connector link as part of it. This connector link is hollow. Place a BS4 67-7187 Screw for Amine Cap, see page P5, in the hollow connector link with the end of the screw protruding from the slot in the top of the BS4 67-7112 Amine Cap, and use a slim screwdriver to turn this screw into the hole in the hydrogen body from which the hook was removed.

The BS4 67-6874 Oxygen, Single Bond and the BS4 67-6916 Oxygen, Indented Double Bond have strong ribs to accept the metal hook of this BS4 67-6726 H-Bond, Hook Type, Hydrogen. When the metal hook is placed over the rib of either of these oxygen atoms, the BS4 67-7138 Hydrogen Wrench, see page P5, then fits over the eight-sided face of the basic hydrogen body, and this body is turned until the hook is brought up securely against the oxygen atom.

Note that one or more BS4 67-7096 H-Bond Spacers, see page P5, can be put on over the hook to increase the bond distance by 0.2Å for each spacer used.

Catalog No.	\$	Product
BS4 67-6726		Hydrogen H-Bond, Hook Type
BS4 67-7207		Repl. Hook for Hydrogen H-Bond



Hydrogen H-Bond, Bayonet Type

Indentation radius 1.35Å about a center 1.66Å from spherical center of hydrogen atom; using upper sets of barbs onshank lengthens H-bond either by 0.20Å or by 0.40Å. Connector link incorporated.

The bayonet connector link fits the slot in the top of the BS4 67-7112 Amine Cap, see page P12, the slots of the BS4 67-6874 Oxygen, Single Bond or the slots of the BS4 67-6916 Oxygen, Indented Double Bond. If the bayonet type connector breaks, it is a simple matter to replace it with a BS4 67-7062 Connector Link, Bayonet H-Bond Replacement which is offered separately, see page P4. White.

Catalog No.	\$	Product
BS4 67-6684		Hydrogen H-Bond, Bayonet Type

Phosphorus



Phosphorus, Tetrahedral

Covalent radius 0.96Å, bond angle 109°30'. Pale yellow.

Catalog No.	\$	Product
BS4 67-6924		Phosphorus, Tetrahedral

Sulfur

Sulfur, Tetrahedral

Sulfur, Tetrahedral is represented by BS4 67-6924 Phosphorus, Tetrahedral when used with the BS4 67-7021 Connector Link, Long, see page P4, resulting in a covalent radius of 1.04Å; double-bond face not differentiated. In other words, to receive Sulfur, Tetrahedral order one BS4 67-6924 Phosphorus, Tetrahedral and four BS4 67-7021 Connector Links, Long. See BS4 67-6924 above.





Sulfur, Digonal

Notches every 90° in sockets. Covalent radius 1.04Å; bond angle 104°. Yellow.

Catalog No.	\$	Product
BS4 67-6957		Sulfur, Digonal

Metal Atoms and Amine Cap

Atom Species	Catalog No.	Bond Arrangement	Color	Bond Angle	van der Waals Radii, Å	Covalent Radii, Å		
						Single Bond	Double Bond	Triple Bond
Metal, Covalent	BS4 67-6973 \$		Silver	90°	1.70*	1.32	–	–
Metal, Ionic	BS4 67-6981 \$		Silver	90°	1.46*	1.32	–	–
Metal, All-Purpose	BS4 67-6999 \$	Non-Specific	Silver	Non-Specific	–	–	*	–
Amine Cap	BS4 67-7112 \$	–	Blue	–	–	–	–	–

* Note: Radius of sphere for constructing atom, all bond angles equal.

Metal



Metal, Covalent

For chelates (Fe, Co, Ni, Cu) or for covalent octahedral bonds. Can also be used for planar configurations. Covalent radius 1.32Å; bond angle 90°; van der Waals radius 1.70Å. Silver.

Catalog No.	\$	Product
BS4 67-6973		Metal, Covalent



Metal, Ionic

For ionic octahedral bonds. Can also be used for planar configurations. Covalent radius 1.32Å; bond angle 90°; van der Waals radius 1.46Å. Silver.

Catalog No.	\$	Product
BS4 67-6981		Metal, Ionic



Metal, All Purpose

A sphere with a diameter corresponding to 2.7Å. Lines of longitude and latitude are embossed at 30° intervals over the surface of the sphere. An indent is at one pole of the sphere. With the aid of the lines of latitude and longitude, the user may orient the sphere in any direction required by a particular construction.

This metal atom has a special connector. It is the BS4 67-7161 Metal Atom Connector Link, see page P5, and consists of a connector link one-half the length of a normal link plus a self-tapping screw. A 1/16 inch hole must be drilled in the sphere in order to accommodate the self-tapping screw.

Two BS4 67-7161 Metal Atom Connector Links are included with each BS4 67-6999 Metal, All Purpose. Silver. For replacement parts see page P5.

Catalog No.	\$	Product
BS4 67-6999		Metal, All Purpose

Amine



Amine Cap

Hemisphere with hollow connector link inserted into flat face and small slot in curved surface. Blue.

The slot in the top of the Amine Cap accepts the bayonet of the BS4 67-6684 H-Bond, Bayonet Type, Hydrogen for temporary connections and the BS4 67-6726 H-Bond, Hook Type, Hydrogen, after the hook has been removed and replaced by a BS4 67-7187 Screw for Amine Cap, for permanent connections. For details, see BS4 67-6726 Hydrogen H-Bond, Hook Type, on page P11.

The Amine Cap is also used with:

BS4 67-6791	Nitrogen Amide to convert to azo nitrogen, see page P9
BS4 67-6825	Nitrogen, Aromatic-5 to convert to azo nitrogen, see page P9
BS4 67-6833	Nitrogen, Aromatic-6 to convert to azo nitrogen, see page P9
BS4 67-6841	Nitrogen, Tetrahedral to convert to amino nitrogen, see page P9
BS4 67-6858	Nitrogen, Tetrahedral-4 to convert to trivalent nitrogen, see page P9

Catalog No.	\$	Product
BS4 67-7112		Amine Cap

Nucleic Acid Helices & Components



- Assembled DNA helix is a unique teaching tool
- DNA, RNA and hybrid DNA-RNA models and kits available
- Available as fully assembled models or as unassembled kit



The fully assembled models are shipped complete with stable base plate. The kits include all the components required to assemble a durable attractive helix of great utility in the classroom as well as the research laboratory.

A one-turn helix is 47 cm (18.5 in) high and approximately 30.5 cm (12 in) diameter. Allow about 42.5 cm (17 in) for each additional turn. The models are supplied with approximately equal numbers of G-C and A-T bases (BS4 67-8318 Adenine-Thymine Base Pair). There is no extra cost if you wish to specify the sequence of base pairs; merely indicate it on your order.

Nucleic Acids Helices Components

Catalog No.	\$	Product
BS4 67-8342		Helix Base
BS4 67-8235		Helix Base Plate
BS4 67-8227		Helix Support Plate
BS4 67-6171		Central Support Rod, 55 cm (21.7 in) for 1.0 Turn Helix
BS4 67-6189		Central Support Rod, 70 cm (27.6 in) for 1.5 Turn Helix
BS4 67-6197		Central Support Rod, 90 cm (35.4 in) for 2.0 Turn Helix
BS4 67-8011		Pentapeptide Chain Unit
BS4 67-8045		Decapeptide H-Bonding Unit

Nucleic Acids Helices

Models	Assembled	\$	Unassembled	\$
DNA Helix, 1.0 Turn	BS4 67-8268		BS4 67-6387	
DNA Helix, 1.5 Turns	BS4 67-8276		BS4 67-6395	
DNA Helix, 2.0 Turns	BS4 67-8284		BS4 67-6403	
RNA Helix, 1.0 Turn	BS4 67-9000		BS4 67-6388	
RNA Helix, 1.5 Turns	BS4 67-9001		BS4 67-6396	
RNA Helix, 2.0 Turns	BS4 67-9002		BS4 67-6404	
DNA-RNA Helix, 1.0 Turn	BS4 67-8270		BS4 67-6389	
DNA-RNA Helix, 1.5 Turns	BS4 67-8278		BS4 67-6397	
DNA-RNA Helix, 2.0 Turns	BS4 67-8286		BS4 67-6405	

Nucleic Acids Helices

Catalog No.	\$	Kits
BS4 67-8300		2'-Deoxy-D-Ribosephosphate Unit
BS4 67-8326		Guanine-Cytosine Base Pair
BS4 67-8318		Adenine-Thymine Base Pair
BS4 67-8334		Adenine-Uracil Base Pair
BS4 67-8243		D-Ribosephosphate Unit

Teaching and Nucleic Acid Sets



Harvard Apparatus offers a complete line of sets. The five most popular Teaching Sets are described below. For complete details, see page P15. Each set is supplied in a sturdy, partitioned, wooden box. Other sets are available. Please call for details

Research and Teaching Set 1

For students. Contains sufficient atoms and connectors to build BS4 67-8205 ATP, a twelve-residue alpha-helix back-bone or the base pairs of the nucleic acids, but not simultaneously.

Catalog No.	\$	Product
BS4 67-6015		Research and Teaching Set 1

Research and Teaching Set 2

For the smaller laboratory. This Set builds 36 peptide backbone segments in helix forms, three base-pair residues of nucleic acid in double helix form, BS4 67-8205 ATP, steroids, etc.

Catalog No.	\$	Product
BS4 67-6023		Research and Teaching Set 2

Research and Teaching Set 3

For the larger laboratory or department where a number of structures, once built, are likely to be left permanently assembled. Constructs 60 peptide backbone segments in helix form.

Catalog No.	\$	Product
BS4 67-6031		Research and Teaching Set 3



Research and Teaching Set 4

Includes the atoms to build small-ring compounds such as BS4 67-0400 Cyclobutane, cyclobutanone, ketenedimer, and derivatives in addition to β -lactams. Also constructs molecules containing functional groups as in alcohols, ketones, aldehydes, esters and amines including their unsaturated derivatives. Useful for demonstrating compounds which undergo photochemical or electron-induced polymerizations as in the acrylates, methacrylates, and other BS4 67-0426 Ethene (vinyl) derivatives.

Catalog No.	\$	Product
BS4 67-6056		Research and Teaching Set 4

Research and Teaching Set 5

Includes the atoms in BS4 67-6056 CPK Models Research and Teaching Set 4 above, but in greater quantity to permit construction of compounds of significant biological interest. For example, antibiotics based on small ring compounds such as those found in the penicillins and cephalosporins.

There are sufficient compounds to build simultaneously two penicillin and two cephalosporin base structures so that the various side chain compounds such as penicillin B, F, K, and flavidin can be assembled and compared.

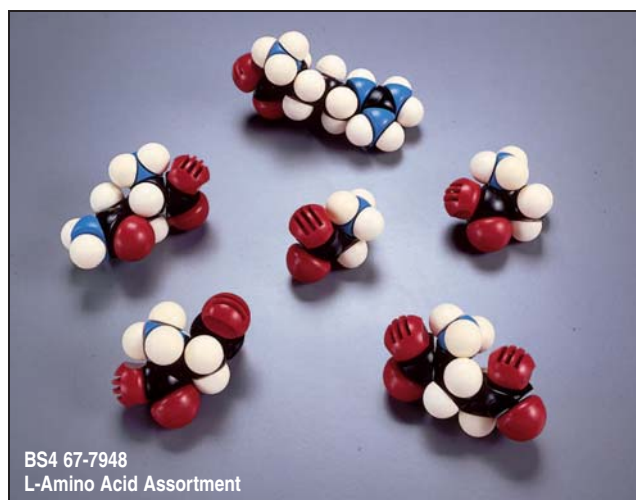
This Set also contains components to build 36 peptide backbone segments in helix forms, three base-pair residues of the nucleic acids in double helix form, BS4 67-8205 ATP, steroids, prostaglandins, and many other important, naturally-occurring compounds.

Catalog No.	\$	Product
BS4 67-6064		Research and Teaching Set 5

Check List for Ordering Individual Components		Research and Teaching Sets					Nucleic Acid Sets	
Catalog No.	Product	1 BS4 67-6015	2 BS4 67-6023	3 BS4 67-6031	4 BS4 67-6056	5 BS4 67-6064	1 BS4 67-6213	2 BS4 67-6221
		\$						
BS4 67-6593	C-Acetylenic Triple Bond	4	6	20	10	10	2	4
BS4 67-6536	C-Amine	12	36	60	15	50	15	45
BS4 67-6551	C-Aromatic-5	6	18	100	15	20	15	50
BS4 67-6569	C-Aromatic-6	18	36	400	15	50	90	300
BS4 67-6585	C-Ethylenic Double Bond	8	20	60	10	30	5	25
BS4 67-6601	C-Fused 5-6 Rings	4	8	20	2	10	15	50
BS4 67-6619	C-Fused 6-6 Rings	4	8	15	2	10	2	4
BS4 67-6600	C-Fused 5-5 Rings	—	—	—	—	—	—	—
BS4 67-6577	C-Tetrahedral	30	60	500	100	100	155	525
BS4 67-6528	C-Tetrahedral-4	—	—	—	4	10	—	—
BS4 67-6544	C-Trigonal-4	—	—	—	4	10	—	—
BS4 67-6874	O-Single Bond	10	36	150	15	40	155	525
BS4 67-6890	O-Double Bond	8	18	100	25	30	35	100
BS4 67-6916	O-Indented Double Bond	12	36	100	10	40	35	135
BS4 67-6791	N-Amide	12	36	60	5	40	20	60
BS4 67-6792	N-Nitrile Triple Bond	—	—	—	—	—	—	—
BS4 67-6825	N-Aromatic-5	3	9	50	5	10	30	100
BS4 67-6833	N-Aromatic-6	6	18	100	5	20	60	180
BS4 67-6841	N-Tetrahedral	4	12	50	10	15	15	45
BS4 67-6858	N-Tetrahedral-4	—	—	—	4	6	—	—
BS4 67-6866	N-Trigonal-4	—	—	—	4	6	—	—
BS4 67-6684	H-Bond, Bayonet Type	2	5	10	—	10	6	20
BS4 67-6726	H-Bond, Hook Type	20	50	100	—	50	60	200
BS4 67-6692	Hydrogen	40	120	1000	175	150	450	1400
BS4 67-6510	Bromide	4	15	60	5	15	2	4
BS4 67-6650	Chloride	4	15	60	5	15	2	4
BS4 67-6676	Fluoride	4	10	70	5	15	—	—
BS4 67-6734	Iodide	4	10	30	5	15	1	4
BS4 67-6957	Sulfur, Digonal	4	8	20	2	15	4	9
BS4 67-6924	Phosphorus, Tetrahedral	4	10	40	—	10	30	100
BS4 67-6973	Metal, Covalent	2	4	20	—	5	2	5
BS4 67-6981	Metal, Ionic	2	4	20	—	5	2	5
BS4 67-6999	Metal, All Purpose	—	—	—	—	—	—	—
BS4 67-7112	Amine Cap	4	12	40	15	15	45	150
BS4 67-7005	Connector Link, Standard	200	500	150	250	550	700	1800
BS4 67-7013	Connector Link, Short	10	50	100	5	50	20	100
BS4 67-7021	Connector Link, Long	10	50	100	5	50	20	100
BS4 67-7039	Connector Link, Locking	10	50	100	—	50	50	200
BS4 67-7047	Connector Link, Carbon	30	60	500	—	60	160	550
BS4 67-7054	Connector Link, Gluing	—	50	300	—	50	50	100
BS4 67-7062	Connector Link, H-Bond	10	25	50	—	25	30	100
BS4 67-7088	Socket	—	25	100	—	30	10	20
BS4 67-7096	H-Bond Spacer	30	75	150	—	80	90	300
BS4 67-7161	Metal Atom Connectors	Not supplied with sets - Used with BS4 67-6999 Metal, All Purpose						
BS4 67-7187	Screws For Amine Cap	Not supplied with sets						
BS4 67-7120	Construction Tool	1	1	3	1	1	1	3
BS4 67-7138	Wrench, H-Bond	1	1	3	1	1	1	3
BS4 67-7146	Calipers	Not supplied with sets						
BS4 67-7179	Pamphlet: Molecules in 3-D	1	1	1	1	1	1	1

Assembled Models

Amino Acids



These L-Amino Acid functional groups complement the BS4 67-7948 L-Amino Acids Assortment. Further, the BS4 67-8011 Pentapeptide Chain Unit and the BS4 67-8045 Decapeptide H-Bonding Unit when used with the functional group, enable the assembly of polypeptide sequences. Models for L-Amino Acids and L-Amino Acids Functional Groups are listed below.

L-Amino Acid Assortment

- No assembly required
- 20 Models Included
- Naturally occurring L-configuration

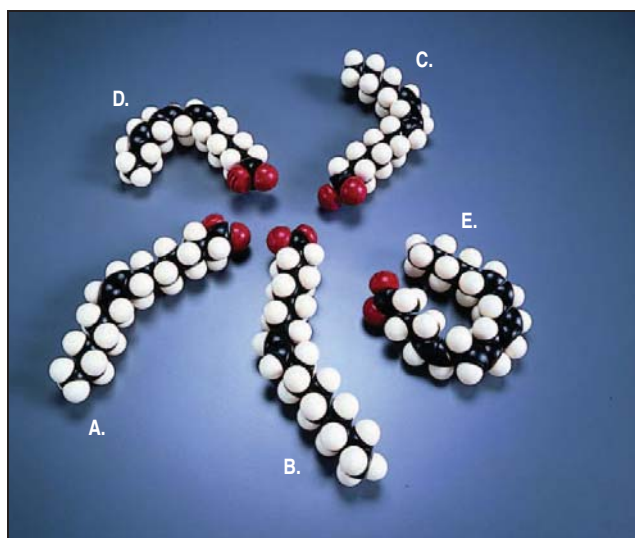
This Assortment contains one each of the 20 assembled amino acids listed below in their naturally occurring L-configuration.

Catalog No.	\$	Product
BS4 67-7948		L-Amino Acid Assortment

Amino Acids		
Catalog No.	\$	Individual L-Amino Acids
BS4 67-3780		L-Histidine
BS4 67-3731		L-Asparagine
BS4 67-3749		L-Cysteine
BS4 67-3798		L-Isoleucine
BS4 67-3715		L-Arginine
BS4 67-3707		L-Alanine
BS4 67-3756		L-Glutamic Acid
BS4 67-3723		L-Aspartic Acid
BS4 67-3764		L-Glutamine
BS4 67-3772		Glycine
BS4 67-3814		L-Lysine
BS4 67-3863		L-Threonine
BS4 67-3855		L-Serine
BS4 67-3806		L-Leucine
BS4 67-3822		L-Methionine
BS4 67-3871		L-Tryptophan
BS4 67-3830		L-Phenylalanine
BS4 67-3848		L-Proline
BS4 67-3897		L-Valine
BS4 67-3889		L-Tyrosine

Amino Acids		
Catalog No.	\$	L-Amino Acid Functional Group
BS4 67-8086		L-Histidyl
BS4 67-3750		L-Cysteinyl
BS4 67-3799		L-Isoleucyl
BS4 67-3732		L-Asparaginyl
BS4 67-6692		Glycyl (Hydrogen)
BS4 67-3724		L-Aspartyl
BS4 67-3716		L-Arginyl
BS4 67-3757		L-Glutamyl
BS4 67-3765		L-Glutaminyl
BS4 67-8128		L-Alanyl
BS4 67-8102		L-Tryptophanyl
BS4 67-3864		L-Threonyl
BS4 67-3815		L-Lysyl
BS4 67-3807		L-Leucyl
BS4 67-3823		L-Methionyl
BS4 67-3856		L-Seryl
BS4 67-8094		L-Prolyl
BS4 67-3890		L-Tyrosyl
BS4 67-3898		L-Valyl
BS4 67-3831		L-Phenylalanyl

Assorted Models



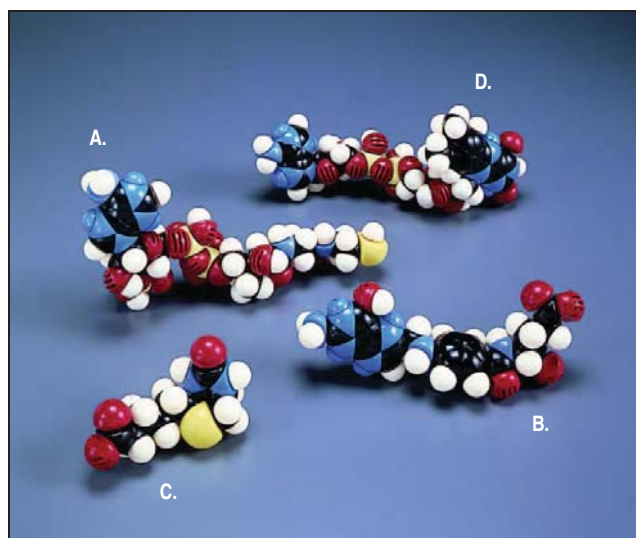
- A. BS4 67-0048 α -Linoleic Acid
- B. BS4 67-0047 Linoleic Acid
- C. BS4 67-0049 Arachidonic Acid
- D. BS4 67-0046 Oleic Acid
- E. BS4 67-0045 Palmitoleic Acid

Assembled Models		
Catalog No.	\$	Product
Purine Nitrogen Base		
BS4 67-8204		Hypoxanthine (6-Oxypurine)
BS4 67-8203		Guanine
BS4 67-8202		Adenine
Pyrimidine Nitrogen Bases		
BS4 67-8220		Thymine
Purine Nucleosides		
BS4 67-8214		Adenosine
BS4 67-8215		Guanosine
BS4 67-8216		Inosine
Pyrimidine Nucleosides		
BS4 67-8232		Thymidine
BS4 67-8233		Cytidine
BS4 67-8234		Uridine
Purine Nucleotide Monophosphates		
BS4 67-8213		IMP: Inosine-5'-Monophosphate
BS4 67-8207		AMP: Adenosine-5'-Monophosphate
BS4 67-8210		GMP: Guanosine-5'-Monophosphate
Purine Nucleotide Diphosphates		
BS4 67-8212		IDP: Inosine-5'-Diphosphate
BS4 67-8206		ADP: Adenosine-5'-Diphosphate
BS4 67-8209		GDP: Guanosine-5'-Diphosphate

Assembled Models		
Catalog No.	\$	Product
Purine Nucleotide Triphosphates		
BS4 67-8205		ATP: Adenosine-5'-Triphosphate
BS4 67-8208		GTP: Guanosine-5'-Triphosphate
BS4 67-8211		ITP: Inosine-5'-Triphosphate
Pyrimidine Nucleotide Monophosphates		
BS4 67-8231		UMP: Uridine-5'-Monophosphate
BS4 67-8225		TMP: Thymidine-5'-Monophosphate
BS4 67-8228		CMP: Cytidine-5'-Monophosphate
Pyrimidine Nucleotide Diphosphates		
BS4 67-8200		CDP: Cytidine-5'-Diphosphate
BS4 67-8230		UDP: Uridine-5'-Diphosphate
BS4 67-8224		TDP: Thymidine-5'-Diphosphate
Pyrimidine Nucleotide Triphosphates		
BS4 67-8229		UTP: Uridine-5'-Triphosphate
BS4 67-8223		TTP: Thymidine-5'-Triphosphate
BS4 67-8226		CTP: Cytidine-5'-Triphosphate

Assembled Models

Assorted Models



- A. **BS4 67-0026** Coenzyme A (CoA)
- B. **BS4 67-0023** FAD: Flavin Adenine Dinucleotide
- C. **BS4 67-0021** Folic Acid
- D. **BS4 67-0022** Biotin

Assembled Models

Catalog No.	\$	Product
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Fatty Acids and Derivatives

BS4 67-0040		n-Dodecanoic (Lauric) Acid
BS4 67-0041		n-Tetradecanoic (Myristic) Acid
BS4 67-0042		n-Hexadecanoic (Palmitic) Acid
BS4 67-0043		n-Octadecanoic (Stearic) Acid
BS4 67-0044		n-Eicosanoic (Arachidic) Acid
BS4 67-0050		Tripalmitin
BS4 67-0048		α -Linolenic Acid
BS4 67-0047		Linoleic Acid
BS4 67-0049		Arachidonic Acid
BS4 67-0046		Oleic Acid
BS4 67-0045		Palmitoleic Acid
BS4 67-0052		Phosphatidylethanolamine (Cephalin)
BS4 67-0051		Phosphatidic Acid
BS4 67-0053		Phosphatidylcholine (Lecithin)
BS4 67-0057		Cardiolipin
BS4 67-0058		Sphingomyelin

Assembled Models

Catalog No.	\$	Product
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Phosphoglycerides

BS4 67-0055		Phosphatidylinositol
BS4 67-0054		Phosphatidylserine
BS4 67-0056		Phosphatidylglycerol

Enzyme Cofactors

BS4 67-0020		Coenzyme A (CoA)
BS4 67-0023		FAD: Flavin Adenine Dinucleotide
BS4 67-0021		Folic Acid
BS4 67-0022		Biotin
BS4 67-0026		NADP: Nicotinamide Adenine Dinucleotide Phosphate
BS4 67-0024		FMN: Flavin Mononucleotide
BS4 67-0027		Pantothenic Acid
BS4 67-0025		NAD: Nicotinamide Adenine Dinucleotide
BS4 67-0031		Tetrahydrofolic Acid
BS4 67-0030		Dihydrofolic Acid
BS4 67-0028		PEP: Phosphoenolpyruvate
BS4 67-0029		TPP: Thiamine Pyrophosphate