

How to Make Your Own Amino Acid Model Without a 3D Printer

Materials Needed

- 3D printed or wooden shapes (see suggestions below)
- super glue
- 6 mm x 2 mm neodymium magnets ([link](#))
- 3 mm x 2 mm neodymium magnets ([link](#))
- 1 marker
- 15 ft of blue paracord (marked) with a diameter of 5/32 inches ([link](#))
- 15 ft of green paracord (unmarked) with a diameter of 5/32 inches
- optional (4 mm aglets for the ends of the blue and green cords)
- color printer

Step-by-Step Instructions

1. Obtain the amino acid shapes. If you do not have access to a 3D printer, here are other options for obtaining the amino acid shapes.
 - a. Option #1: Order 3D printed parts from 3D printing websites such as the following:
 - i. Option 1a: https://www.xometry.com/capabilities/3d-printing-service/?utm_term=print%20my%203d%20model&utm_campaign=goog_xom-buyer_search_nonbrand_all_individual_additive&utm_source=adwords&utm_medium=ppc&hsa_acc=3789459769&hsa_cam=23460677644&hsa_grp=198359369664&hsa_ad=792651008852&hsa_src=g&hsa_tgt=kwd-48215975050&hsa_kw=print%20my%203d%20model&hsa_mt=e&hsa_net=adwords&hsa_ver=3&gad_source=1&gad_campaignid=23460677644&gbraid=0AAAAADn8J0_EJmq_aQPK_YARpyIAZTku-Z&qclid=Cj0KCQiAp-zLBhDkARIsABcYc6tTpnPGoZRWlv18k8FdpjoCYQ_FltWlo3xALRpHFQ9e4kziWz3vX5IaAiCAEALw_wcB
 - ii. Option 1b: https://www.hubs.com/3d-printing/?device=c&position=&utm_source=adwords_g&utm_medium=cpc&utm_campaign=10035253401&utm_content=104752948527&utm_term=3d%20printing%20prototyping&hsa_grp=104752948527&hsa_ver=3&hsa_src=g&hsa_kw=3d%20printing%20prototyping&hsa_ad=649629278639&hsa_cam=10035253401&hsa_net=adwords&hsa_mt=p&hsa_acc=4596651596&hsa_tgt=kwd-13745773793&gad_source=1&gad_campaignid=10035253401&gbraid=0AAAAACYUT3rReJ0SVLRXty6aXq7zBeNTo&qclid=Cj0KCQiAp-zLBhDkARIsABcYc6uQFyZt2om_EGAd--aPpVjDzWWDaif1mhauzqxjr4LIEcikt9PMtYaAiFzEALw_wcB
 - iii. Option 1c: https://quickparts.com/3d-printing-v2/?cq_con=189875563881&cq_plac=&cq_net=g&cq_plt=gp&utm_term=3d%20prototype%20printing%20companies&utm_campaign=QP+-+32pts+-+NA+-+Search+-+3D+Printing&utm_source=google&utm_medium=ppc&hsa_acc=9728598533&hsa_cam=20481502978&hsa_grp=189875563881&hsa_ad=790325508841&hsa_src=g&hsa_tgt=kwd-575910957961&hsa_kw=3d%20prototype%20printing%20companies&hsa_mt=b&hsa_net=

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- Note: If these websites require .stl files you can download the STL files for the amino acid models from [Tinkercad](#) or [Google Drive](#) + [Methionine \(white\)](#).
 - We recommend downloading the "Methionine" (the white sphere) separately because it needs to have supports and a raft/brim for plate adhesion. Alternatively, you can print the entire set with raft/brim plate adhesion and do more clean-up later.
 - The table below provides coding for the amino acids needed for one group's kit.

Download the .stl Files			
Amino Acid Model	Filament Color	Tinkercad Link	Google Drive .stl
lysine and glycine	red	lysine and glycine (red)	https://drive.google.com/file/d/1WqeB4SIU4a_1v_JSEoTqZjeKXtvF2nfa/view?usp=drive_link
leucine	orange	leucine (orange)	https://drive.google.com/file/d/1tTB_XC2Bxf5qPRg7RgBY7kaA5MbD4gdu/view?usp=drive_link
valine	yellow	valine (yellow)	https://drive.google.com/file/d/1C2zEaWEoGrYAt1HkEnqllOE6xM9joxK/view?usp=drive_link
phenylalanine and serine	green	phenylalanine and serine (green)	https://drive.google.com/file/d/1pJKk1yoTEGG3b3y-IKIIEW34eGoYk_1b/view?usp=drive_link
alanine and arginine	blue	alanine and arginine (blue)	https://drive.google.com/file/d/1DBRK0GAM4UZwpNNKJlPiv24Xxyry0hHb/view?usp=drive_link
glutamic acid	pink	glutamic acid (pink)	https://drive.google.com/file/d/1C5Bd9saXI9C1TOI8EdXOHsjaWXtTjL1Q/view?usp=drive_link
glutamine	gray	glutamine (gray)	https://drive.google.com/file/d/1eSCeGtmHh5Z4X30-vaXz14WoOEcJ48Uj/view?usp=drive_link
threonine	black	threonine (black)	https://drive.google.com/file/d/1Zf-D2QkRBEEEX-BIEf9UAdR8Cy7aGzksi/view?usp=drive_link

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Download the .stl Files			
methionine	white (note: print with raft and supports)	methionine (white)	https://drive.google.com/file/d/14KDskPCvNVLhzkD6go60oaRGWIsMwIXS/view?usp=drive_link

- b. Option #2: Use wooden blocks
- i. Teachers could create their own models using kits similar to this one:
https://www.michaels.com/product/wood-crafting-assortment-kit-by-creatology-10690162?com_id=pdp_AlsoLike&path=youMayAlsoLike
1. This option might require a drill to make holes in some of the wood models for the paracord.
 2. This option may require paint.

Amino Acid and Shape Legend

Amino Acid	Corresponding model shape codons
methionine	green sphere
lysine	gray rounded cube 1
leucine	green rounded cube 2
valine	green multifaceted polygon
phenylalanine	white hexagon
alanine	blue "cylinder"
glutamic acid	gray triangle 1
glutamine	white triangle 2
Glycine	gray cube 1
threonine (small magnet)	blue cube 2
serine	white indented (lined) cube
arginine (small and large magnet holes on each side)	blue rectangular prism

2. Attach magnets
- a. Once you have the amino acid parts, you will need to attach the magnets.
 - b. Super glue the magnets on using the sizing specifications in the table below. Note these magnet sizes were chosen based upon the .stl files sizes. Please check your amino acid size and obtain the best magnet fit.

Magnet Specifications			
Amino Acid Model	Shape and Color	Number and Size of Magnets	Number of 3D Prints Needed for Kit
methionine	white sphere	none	3
lysine	blue rounded cube 1	2 x 6 mm x 2 mm	3
leucine	orange rounded cube 2	2 x 6 mm x 2 mm	4

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Magnet Specifications			
valine	yellow multifaceted polygon	2 x 6 mm x 2 mm	3
phenylalanine	green hexagon	2 x 6 mm x 2 mm	4
alanine	blue cylinder	2 x 6 mm x 2 mm	4
glutamic acid	pink triangle 1	2 x 6 mm x 2 mm	3
glutamine	white triangle 2	2 x 6 mm x 2 mm	4
glycine	yellow cube 1	2 x 6 mm x 2 mm	10
threonine	black cube 2	2 x 3 mm x 2 mm (small)	3
serine	green indented (lined) cube	2 x 6 mm x 2 mm	3
arginine	blue rectangular prism	2 x 3 mm x 2 mm (small) and 2 x 6 mm x 2 mm (large)	4

- c. Note: The 3D .stl prints are set up to accommodate 6 mm x 2 mm neodymium magnets and 3 mm x 2 mm magnets for specific amino acids that do not have holes for the 3 mm x 2 mm magnets.

3. Ensure the models fit together by testing the poles of the magnets. Label the north pole of the magnet with a marker and distribute north- and south-pole facing magnets evenly on individual models.

4. Paracord for the modeling

- Order the following items for completing your modeling kit: [RELIABILT 0.1563-in x 38-ft Braided Polypropylene Rope \(BLUE\)](#)
- Each kit gets approximately 15 ft of blue paracord and 15 ft of green paracord.
- Mark the blue paracord with a marker to indicate the approximate location of the amino acids (electrical tape may be used as an alternative, but it might limit the ease of sliding the amino acids onto the wire).
- The placement of these marks will impact the final protein shape.
- We suggest constructing one model first and then marking your cords accordingly. This way, the proteins in your class will have a similar conformation.
- The cords we use were constructed in the following manner.
 - Tie a loop at one end of the cord then measure from the loop and mark the cord at the following locations: 5 in., 6.5 in., 14.5 in., 22 in., 31.5 in., 38 in., 43 in., 50 in., 56.5 in., 61.5 in., 71 in., 77 in., 83.5 in., 91.5 in., 96.75 in., 104.5 in., 111.5, 118.5 in., 128 in., 133.5 in., 138 in., 143 in.



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5. Print the **Amino Acid Placemats** on a color printer.
 - a. To help students keep track of the modeling components, print this amino acid placemat using a color printer: [Amino Acid Placemat](#).

Now you have a complete set of 3D printed amino acid models ready for classroom use! Enjoy teaching and exploring with these interactive models.