Drastic Plastic Measures

Adapted for Virginia School for the Deaf and the Blind Field Trip
4/13/23

Our Guests

- There will be 8 students (referred to here as "guests" to distinguish from JMU students). They will be joined by their teacher, Mr. Dylan Boeckman (JMU Chemistry alum), and two orientation and mobility (O&M) specialists- Lisa and Sallie.
- Six are Freshmen in Biology, two are Juniors in Chemistry.
- Four have low-vision and four are blind. They are self-selecting groups so some will be mixed with respect to visual impairment and some will not.
- JMU Chem. instructor, Lindsey Sequeira will lead the lab. Two JMU students will be paired with each group of 2 VSDB students.

General tips and information for volunteers

- It's perfectly OK to ask them to describe their vision, "how much vision do you have?", "how do you use your vision?" They are accustomed to and comfortable answering these questions and this information will help you as their facilitator.
- There may be students who are very capable but will shy away from doing the lab and engaging in discussion. Charlotte is one of these students. If you are unsure how to best facilitate your group, don't hesitate to ask Dylan or one of the O&M specialists.
- When they are directed to use a beaker, silicon mold, etc. it may take a little while for them to process what they are being asked to do and how to find it so give them time to get the items themselves first. As they are reaching for items (e.g., beaker, syringe, mold), it's OK to say "the beaker is to your left, a little more to your left", "would you like me to get the beaker for you?", "do you need help finding the beaker?"
- We will have a photographer taking professional-quality photos so please refrain from taking your own photos. We will share them with you for you to share publicly if you wish. All students have a signed photo release.

For the last part (plastic waste analysis):

- Reading tactile graphics takes longer than visual graphics. If they are losing focus, it's OK to say "let's look at this together".
- Help them first understand the big picture (the whole) of what the graph represents before focusing on the labels and data points (the parts that make up the whole).
- Encourage them to discuss what they observe with the graphics and to think about the answers to the questions about the graph (they will have those in braille too).

Background and Science 101 of "Drastic Plastic Measures"

- Chitosan is derived from chitin, which is a sugar polymer abundantly expressed in shells of shrimp and other crustaceans. Several years ago, Chemistry professor, Dr. Boardman and her students published their research on creating bioplastic films using chitosan with a variety of plasticizers.
- Plasticizers are molecules that give a plastic it's physical properties by increasing the space between the polymer chains (of the plastic) to different degrees to give it varying

levels of flexibility. A common plasticizer used with petroleum-based plastics that you may have heard of due associated health concerns are phthalates.

- For example, shampoo bottles, vinyl shower curtain liners, and plumbing pipes in your home are all made from the same plastic polymer (polyvinyl chloride or PVC) but have varying flexibility, bendability, etc. because they contain different plasticizers.
- Different types of petroleum-based plastics have different levels of recyclability and degradability. The recyclability of PVC is designated as 3. These plastics are considered not recyclable and when disposed of, take ~450 years to decompose.
- Bioplastics are being studied as an environmentally-safe alternative due to both their biodegradability and less toxic extraction and manufacturing process. Starch, cellulose (long sugar polymers), and protein-based polymers are some of the more common bioplastics. Chitosan has been used to make plastic bags and packaging material. Dr. Boardman's lab and others continue to study other potential uses for Chitosan-based bioplastics.
- In this lab, we will make 4 different types of Chitosan films. Each will be made with a different (environmentally-friendly) plasticizer, giving them different physical properties. The plasticizers we will be testing are all sugar alcohols, which are derived from plants. You have heard of these because some are used as lower-calorie sweeteners to replace sugar. In this lab, we will test the following sugar alcohols as plasticizers: 1,3-propanediol, glycerol, xylitol, and mannitol.
- After mixing the chitosan solution, plasticizer and dilute acetic acid (to bring up to total volume), we will add the solution to small silicon candy tray molds and dry for one hour.
- After drying the films, we will test and score the films for fold, stretch, and twisting properties (e.g., how far can it stretch before breaking).
- In addition to practicing general Chemistry lab techniques, this experience also incorporates the important distinction and relationships between qualitative and quantitative data and interpreting different types of data visualization. **See here for photos** and here for an idea of what this lab experience will look like.

Protocol with Volunteer Notes- use this along with the traditional lab protocol version, p5.

<table>
<tr><th></th><th>Steps</th><th>Volunteer Notes</th></tr>
<tr><td>Introduction to people and spaces</td><td>1. As a group, guests and JMU volunteers will introduce themselves
2. Dylan will orient his students to the spaces and items they will be using.</td><td>1. Students introduce yourself including where you are from, your year at JMU, and your major. Others introduce name and your role at JMU.
2. Learn and use their names
3. Watch and learn how Dylan and staff orient our guests so you can reinforce and assist in an effective way throughout the lab.</td></tr>
<tr><td>Lab Introduction</td><td>Prof. Sequeira will introduce
polymers using molecular models with braille labeling
the connection between polymers and familiar plastics
plasticizers and how different ones used with the same polymer result in different products (e.g., shower curtain liner and PCV pipe which we will have for them to feel).</td><td>Note: for the polymer models
Small white spheres: Hydrogen
Red spheres: Oxygen
Black spheres: Carbon
Blue sphere: Nitrogen</td></tr>
<tr><td>Lab Part I: Preparing Chitosan Film Solutions- see “lab protocol” doc. on p.5 for details</td><td>Prof. Sequeira will guide our guests through the protocol, step-by-step, for preparing the chitosan & plasticizer solutions that will later be added to molds to make the chitosan films in part II. They will first practice using the syringes with water which will allow also for discussion about viscosity.
They will do this by adding 3 different solutions to a beaker using a new syringe for each solution.
First, practice using syringes with water to pull up 2, 3, and 5 ml.
Step 1: Add 5ml of chitosan to beaker
Step 2: Add 3 ml of plasticizer (each group will have a different one)
Step 3: Add 2 ml of dilute acetic acid.
Step 4: Add a magnetic stir-bar to the beaker
Step 5: Place beaker with stir-bar on stir-plate, set dial to 7, DO NOT turn dial on right (heat). Stir for 15 minutes.</td><td>In addition to Prof. Sequeira walking us through this part, our guests will have a braille document with the volumes.
As our guests are pulling liquid up the syringe, volunteers will guide them by saying “pull up a little more or too much- push down to remove a little, etc.”
Volunteers will set the beakers with stir-bars on stir-plates (to ensure heating element not accidentally turned on) and then turn dial to 7 to start stirring. Place beakers in center so stir-bar continues stirring.
Dispose of the syringes in “sharps” container</td></tr>
</table>

Developing Quantitative Analysis Methods (during 15-minute stir time)	Prof. Sequeira will walk our guests through this part. • They will be tasked with deciding on a numerical scale (e.g., 1-3, 1-5, 1-10) for the three physical properties of the films (fold, twist, and stretch). They will use this in part III to assign a number that represents variation between the physical properties of the film (for each test).	Volunteers will: • Help facilitate the conversation, providing any clarification or redirection if needed. • Fill in table 2 reflecting what our guests decide on for their numerical scale.
Lab Part II: Pouring Films	Using new syringes, our guests will add 2mL of the solution from their beaker to the silicon mold. Each mold will be placed on a separate hot-plate for 1 hour to allow the films to dry.	• Volunteers will remove the beakers from the stir-plates and set the heat dial to 85° (setting 2) to prepare for the next step. • Volunteers will help guide our guests using the syringes again. • Once solution is added, volunteers will place molds on the plates. We will have one mold per plate, make sure they are placed in the center.
Lunch	While the films are drying, our guests will have lunch in PCB 3348, which is a small student conference room. It will be a selection of sandwiches and salad.	Volunteers are welcome to join us for catered lunch. If we don't have enough chairs in PCB 3348, you are welcome to grab lunch and eat elsewhere.
Lab Part III: Testing film properties, collecting, and sharing data	• Prof. Sequeira will guide our guests through testing their film and the provide control film for the ability to fold, twist, and stretch without breaking • Using the notes recorded on table 2, our guests will assign a number to their test film and control film. Prof. Sequeira will lead our guests in sharing their data and discussing conclusions such as "which film would be best the best for x type of application (e.g., replacing plastic wrap for food storage).	• Volunteers will remove the molds from the plates and turn off the heat. • Volunteers will record the values assigned by our guests on table 3. • If their films didn't dry enough, we will have a prepared backup film for each group, let someone know if you need one.
Why this research matters- plastic waste data analysis- see data anal. guide	• Prof. Sequeira will lead discussion about the graphs (in the separate data document).	• Review the graphs and questions/answers before the event so you are prepared to provide clarification and facilitate the conversation in your group.

LAB PROTOCOL

Lab Part 1: Preparing Chitosan Film Solutions

1. Using a **different 5mL syringe for each solution**, add the appropriate volumes of chitosan, plasticizer, and dilute acetic acid to the beaker to make your solutions as shown in Table 1. Dispose of syringes in the designated waste basket when finished.

Table 1. Volume guide for film preparation

Volume of Chitosan (mL)	Volume of Plasticizer (mL)	Volume of Dilute Acetic Acid (mL)	Final Volume (mL)	Final Concentration of Plasticizer (%)
5	3	2	10	30

Plasticizers:

Group 1: 1,3-Propanediol
Group 2: Glycerol
Group 3: Xylitol
Group 4: Mannitol

2. Add a magnetic stir bar to each beaker and place on the stir plates located in the hood. Place the beaker as close to the center of the plate as you can. The stir bar should be in the center of the beaker. You will hear a rapid clinking sound if the stir bar is not centered.
3. Set the stir plates (the **LEFT)** dial to 7. **DO NOT** turn the dial on the right- this will heat the plate which you don't want yet.
4. Let the solutions stir for 15 minutes

Developing Quantitative Analysis Methods

5. Develop a method to **quantify** each of the three physical properties and describe it in Table 2 below. Recall that **quantitative data** refers to numerical data.
    a. First decide on a numerical scale (i.e., 1-3, 1-5, 1-10)
    b. Then assign a number for each test that represents the variation between the physical properties of the films. For example, in the fold test, 1 could be dry and brittle and 5 could be very sticky.
6. After 15 minutes, turn off the stir plate and remove the beakers.
7. Set plates to 85°C (Setting 2)

Lab Part II: Pouring Films

8. Use the syringes to **add just enough of the solution into the molds to form a thin layer along the bottom**; this should be approximately 2ml. If you add too much, they will not dry in time.
9. Place molds on the hotplate for 60 minutes. During this time, we will go to lunch.

Lab Part III: Testing the Biofilms

10. Have each group member examine your films for fold, twist, and stretch to get a sense of. the variation between the control, and your plasticizers. Be careful not to break them.

11. Have each group member quantify the two films using the methods you developed and record the data in table 3 and calculate averages.

Table 2. Quantification of Physical Characteristics

Physical Properties	Number Scale	Quantification Method
Fold		
Twist		
Stretch		

Table 3. Film Properties

Control Film

Trial	Fold	Twist	Stretch	Avg Fold	Avg Twist	Avg Stretch
1						
2						

Plasticizer Film Properties

Trial	Fold	Twist	Stretch	Avg Fold	Avg Twist	Avg Stretch
1						
2						

DATA ANALYSIS DISCUSSION GUIDE

Figure 1A & 1B. Modified versions for guests: Figure 1-combined-braille, and Figure 1-combined Low-Vision

Discuss with your group:

- What % of the plastic generated by the packaging industry is wasted each year?
- Compare this to the % wasted for the building and construction industry, what might explain this discrepancy between these two industries?

FULL GROUP QUESTION AND DISCUSSION:

- Between the packaging industry, the consumer products, the transportation industry and building/construction industry, rank the order the % of generated plastic that is wasted each year from highest to lowest? (ANSWER: packaging, consumer products, transportation, building).
- If you compare the packaging and construction industries, what might explain this discrepancy?

Figure 2 and Table 1

Discuss with your group:

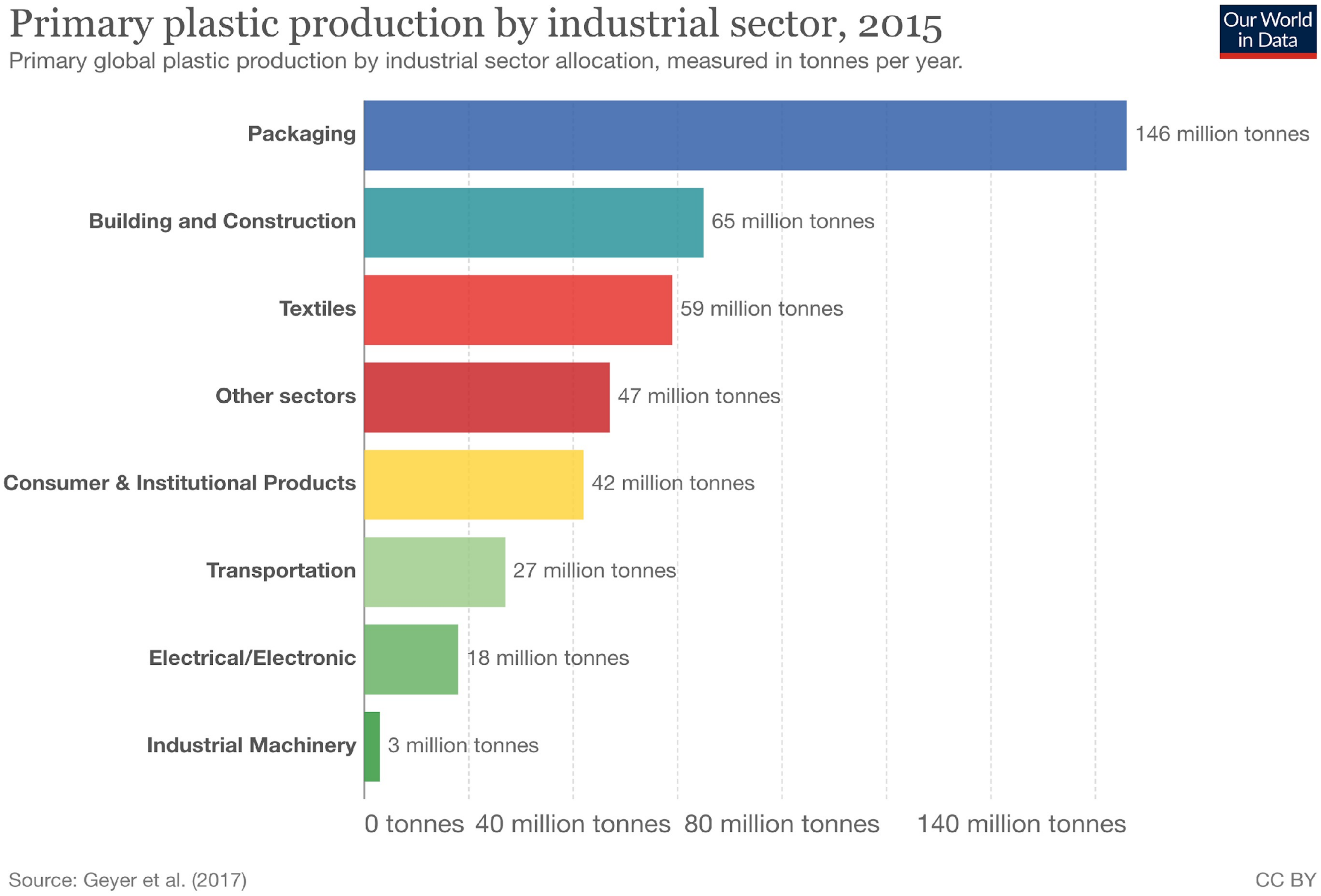
- Based on your interpretations, what type of plastic do you consider to be the most problematic?
- Discuss the types of products you use that contain this type of plastic.

FULL GROUP QUESTION AND DISCUSSION:

- Which type of plastic do you consider to be the most harmful to the environment? (Type 1, 2, 3, 4, 5). Not one right answer. Expect 3, 4 or 5 for different reasons. Students should consider, how much is made, how much can be recycled, and how long it takes to decompose.

Facilitator's Version

Figure 1A. Bar chart. See *Figure 1 combined- braille* for how this chart and 1B will be combined into one braille graph for our blind guests. and *Figure 1 combined- LV* will be given to our guests with low vision



Facilitator's Version

Figure 1A. Bar chart. See *Figure 1 combined- braille* for how this chart and 1A will be combined into one braille graph for our blind guests and *Figure 1 combined- LV* will be given to our guests with low vision

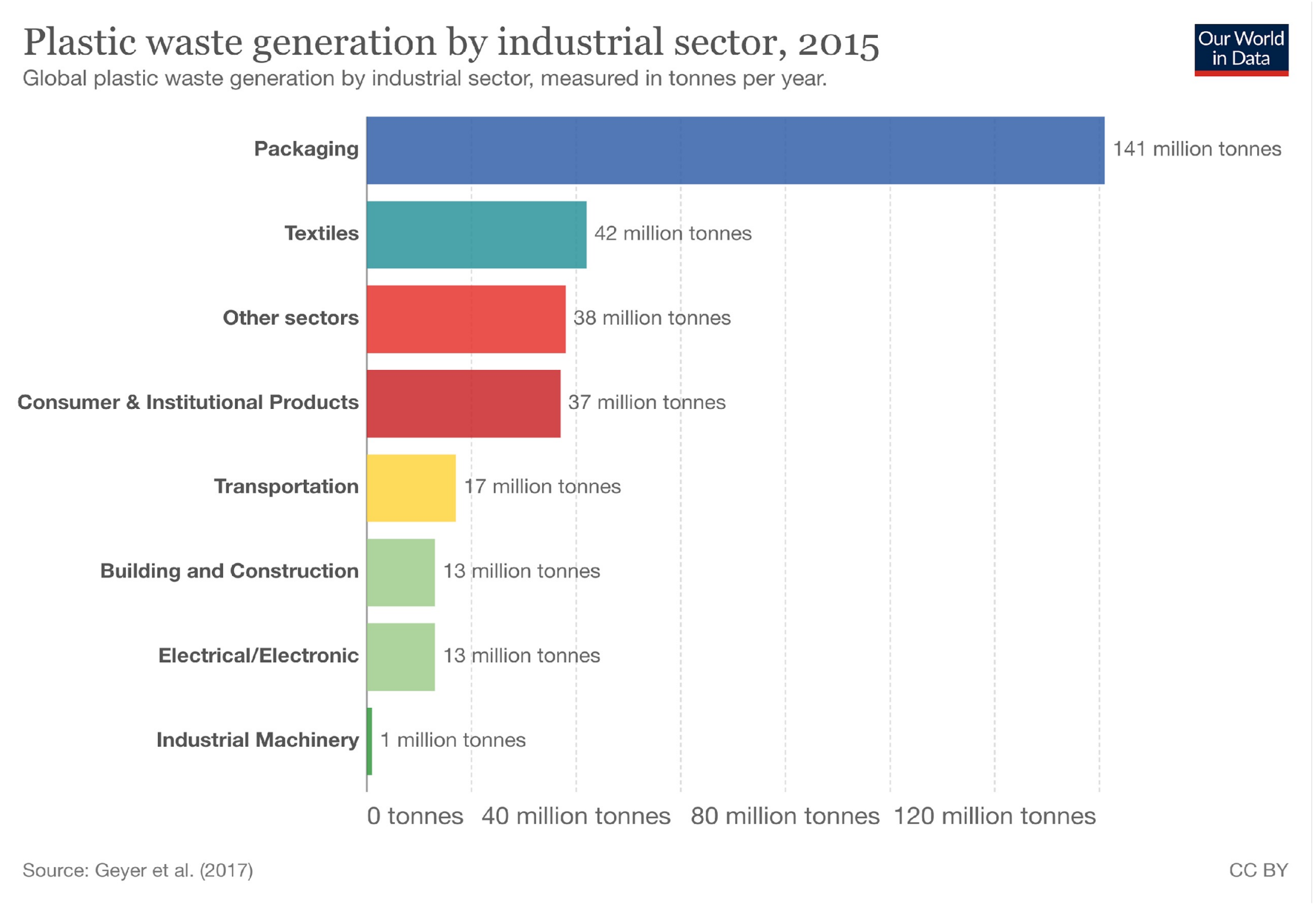


Figure 1 combined- Braille. This chart combines figures 1A and B. The orange dot represents the percentage wasted. To the left of the dot is the amount wasted and to the right is not wasted. You can follow the braille line from the dots to the x-axis for the percentage wasted value (e.g. 96% wasted for packaging plastic on the top row). That 96% comes from dividing the packaging values on Figure 2B by 2A (141 tons/146 tons = 96% wasted)

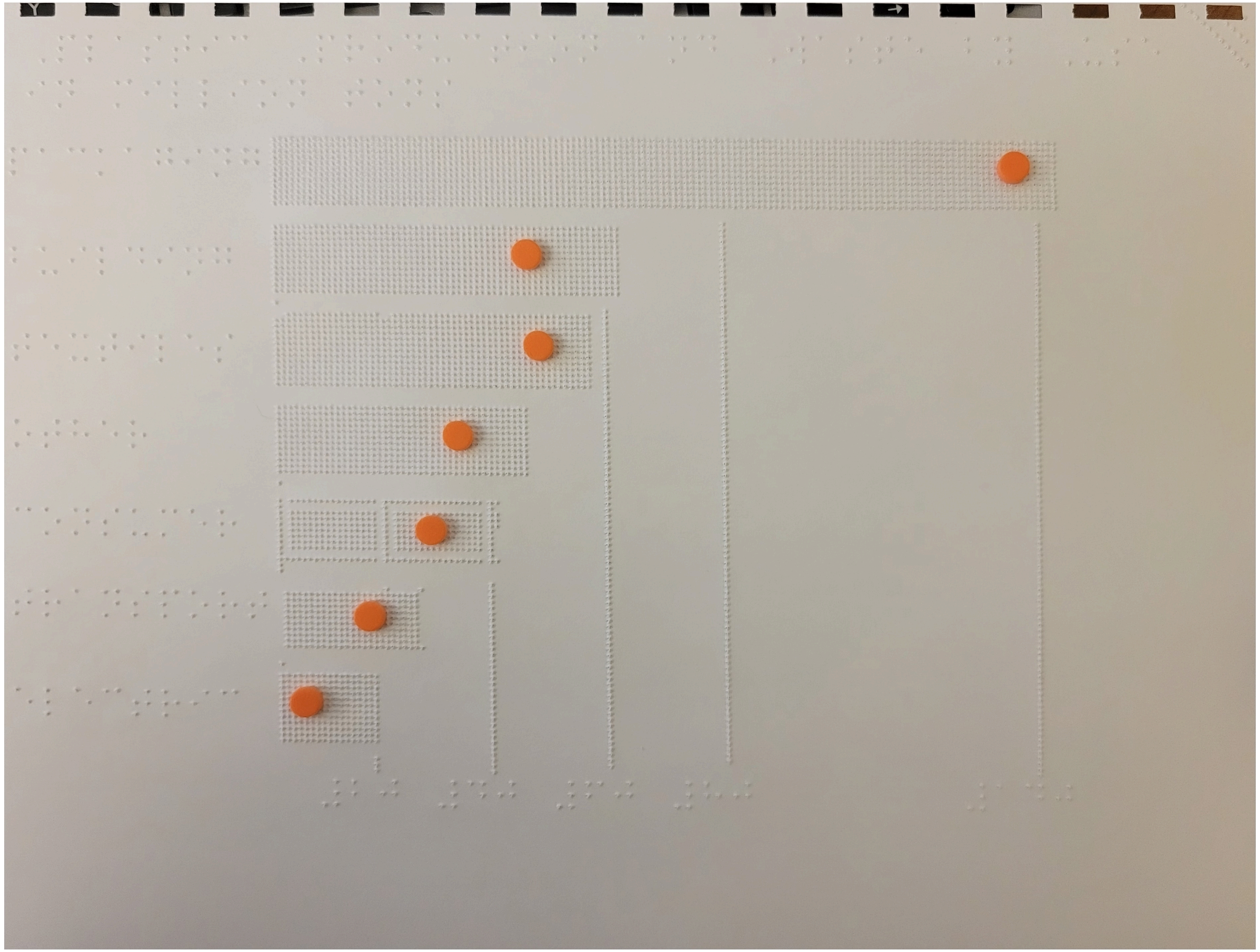
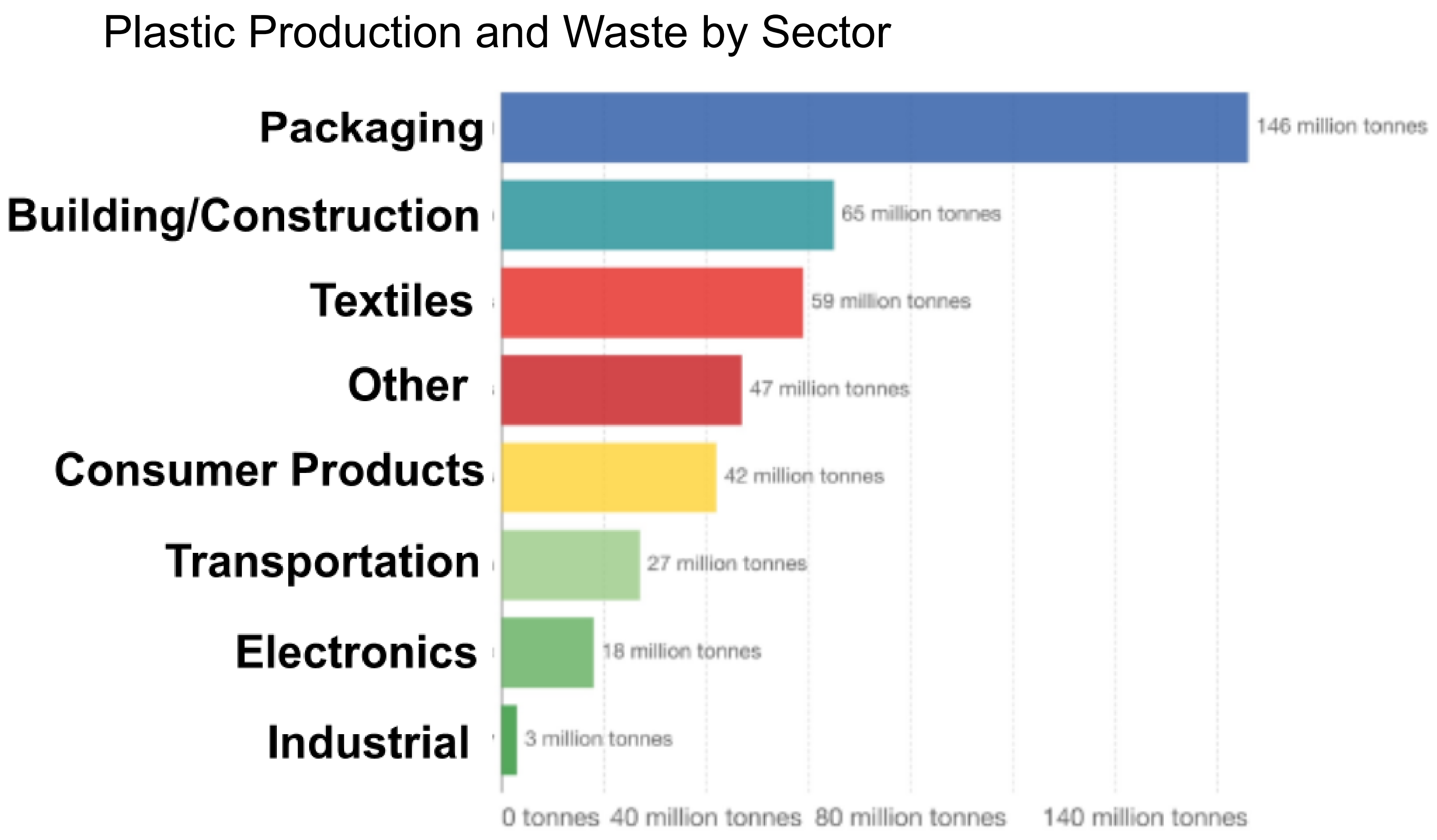


Figure 1 combined- LV
This will have a bold lines drawn from the bar to the appropriate value on the x-axis to indicate percent wasted. This is to avoid needing to go back and forth between two graphs and dividing values to get the important information



Original Table 1.

Plastic #	Types of Plastics	Common Uses	Recycling Rate	Recycled Into	Decomposition Time (Perfect Conditions)
1	Polyethylene terephthalates (PET)	Soft drink, water bottles, clothing, carpet	29%	Polar fleece clothes, backpacks and carpets.	>450 years
2	High Density polyethylene (HDPE)	Plastic bags, shampoo bottles, milk bottles, packaging	30%	Non-food bottles like cleaning solution, motor oil	100 years
3	Polyvinyl chloride (PVC)	Makeup containers, plumbing pipes, vinyl flooring, shower curtains, credit cards	Considered not recyclable <1%	NA	>450 years
4	Low-density polyethylene (LDPE)	Grocery bags, garbage bags, sandwich bags, squeezable condiment bottles, water bottle caps, kids toys	Not accepted by most recycling centers. 6%	Floor tiles, shipping envelopes, outdoor furniture	500-1000 years
5	Polypropylene (PP)	Yogurt containers, margarine containers, syrup bottles, disposable cups, diapers, packaging material	1-3%	Plastic lumbers, park bunches, auto parts	20-30 years

For low-vision guests, no braille version.

Table 1:

Plastic	Uses	Percent Recycled	Decomposition Time
PP	Yogurt Cups	1-3%	20-30 Years
LDPE	Grocery Bags	6%	500-1000 Years
HDPE	Milk Cartons	30%	100 Years
PVC	Pipes, Credit Cards	1%	450+ Years
PET	Water Bottles	29%	450+ Years

Figure 2. Original Chart

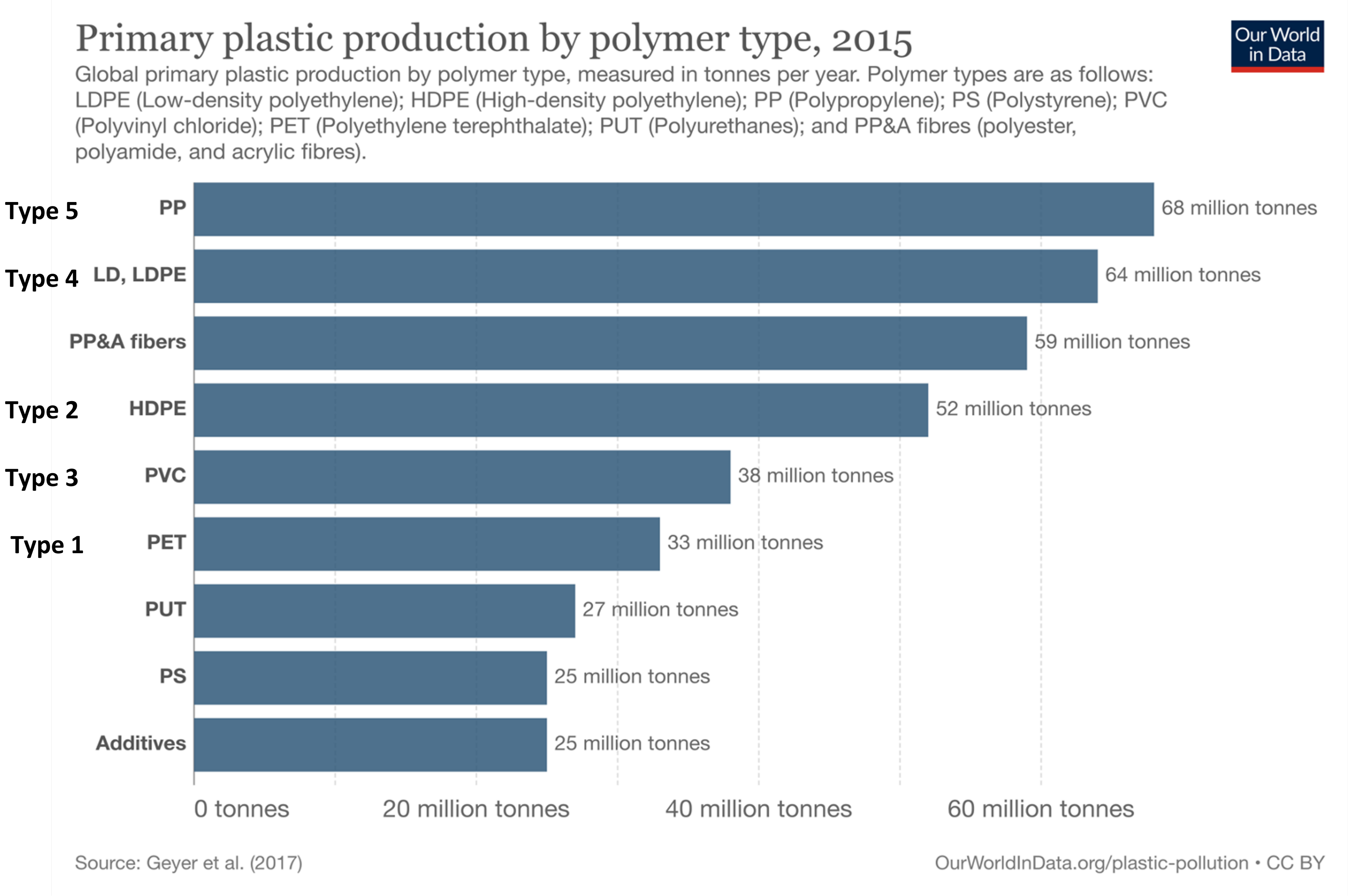


Figure 2. Version for low-vision students. Braille version will be provided