

Submission ID #: 69900

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Project Page Link: <https://review.jove.com/account/file-uploader?src=21319548>

Title: Real-World M3-BREATHE: Toward Multimodal Mobile Monitoring of Behaviour, Respiration, and Exposures for Treatment and Health Evaluation

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Author Questionnaire

1. **Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**
2. **Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done!**
3. **Filming location:** Will the filming need to take place in multiple locations? **No**
4. **Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **Yes**

Current Protocol Length

Number of Steps: 13

Number of Shots: 59 (41 SC)

Interviews

Videographer: Obtain headshots for all authors available at the filming location.

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Wenbo Guo:** I develop M3-BREATHE application to integrate behavior, respiration, and environment, examining how mobility influences real-time health risks and outcomes.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~Describe the research gap or limitation in existing methods and how this protocol addresses them.~~

- 1.2. **Wenbo Guo:** Existing studies use static locations and miss mobility; this protocol captures high-resolution, synchronized, individual-level data across behavior, physiology, and exposures.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Wenbo Guo:** M3-BREATHE enables real-time measurement of personalized exposure, inhaled doses of environmental pollutants, and physiological responses during daily activities and travel.

1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.4. **Wenbo Guo:** The key challenge is reliable device calibration, synchronization, and sustained participant compliance in real-world, long-term monitoring.

1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

1.5. **Wenbo Guo**: Future work can integrate AI interventions, genomics, and cross-city deployments to study causal pathways and improve precision environmental health.

1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

Videographer: Obtain headshots for all authors available at the filming location.

Testimonial Questions (OPTIONAL):

Videographer: Please capture all testimonial shots in a wide-angle format with sufficient headspace, as the final videos will be rendered in a 1:1 aspect ratio. Testimonial statements will be presented live by the authors, sharing their spontaneous perspectives.

- Testimonial statements will **not appear in the video** but may be featured in the journal's promotional materials.
- **Provide the full name and position** (e.g., Director of [Institute Name], Senior Researcher [University Name], etc.) of the author delivering the testimonial.
- Please **answer the testimonial question live during the shoot**, speaking naturally and in your own words in **complete sentences**.

What problem in your field of research does your JoVE article address?

- 1.6. **Wenbo Guo, Associate Research Professor, Fudan University:** (authors will present their testimonial statements live)

1.6.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

How does the video format of your article help you to share your work with the broader scientific community?

- 1.7. **Wenbo Guo, Associate Research Professor, Fudan University:** (authors will present their testimonial statements live)

1.7.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

Ethics Title Card

This research was approved by Peking University's Human Research Ethics Committee

Protocol

Videographer: Please always record an audio slate while filming each shot mentioned in the shotlist.

2. Setup and Configuration of Wearable Physiological and Portable Environmental Sensors

Demonstrator: Wenbo Guo

- 2.1. To begin, wear the sensor-integrated shirt or chest strap directly against the skin beneath the clothing to ensure optimal contact [1]. Adjust the fit so that it is snug and comfortable without constraining breathing or movement [2]. Confirm stable skin contact by checking that the sensor does not slip during deep inhalation [3].
 - 2.1.1. WIDE: Talent assisting participant in wearing the sensor-integrated shirt or chest strap under clothing. *Videographer: Please obtain CU shot as well for this shot.*
Videographer's Note: Shot 2.1.1 was changed to the talent wearing the sensor himself, so it's not a wide shot.
 - 2.1.2. Close-up of talent adjusting the shirt or strap for a snug fit.
 - 2.1.3. Close-up of participant taking a deep breath while the sensor remains stable.
- 2.2. Ensure the sensor is fully charged and pair it with the smartphone via Bluetooth for real-time monitoring [1]. Confirm successful binding and automatic synchronization of multimodal data streams between the smartphone and the linked devices through the dedicated application [2]. After choosing the heart rate sensor, verify that the heart rate and R-R-interval, or RRI (*R-R-I*) values are being dynamically recorded on the smartphone [3].
 - 2.2.1. LAB MEDIA: 2.2.2.mp4. 0:00 – 0:04. *Video Editor: Please blur the text "BRT05627" and "FB:15:1C:A4:7C:F0"*
 - 2.2.2. LAB MEDIA: 2.2.2.mp4. 0:05 – 0:11. *Video Editor: Please blur the text ECTRI at timestamp 0:05–0:07 and the text "BRT05627" under "Devices" at the top at timestamp 0:08–0:11*
 - 2.2.3. LAB MEDIA: 2.2.3.mp4. 0:00 – 0:09. *Video Editor: Please blur the text "BRT05627" at two places within the screen capture.*
- 2.3. To set up the smart wristband, choose the non-dominant wrist and secure the device proximal to the ulnar styloid process [1]. Adjust the strap to ensure proper sensor-skin contact while allowing insertion of one fingertip [2]. Confirm that the photoplethysmography or PPG (*P-P-G*) sensor maintains constant and flush contact with the skin [3].
 - 2.3.1. WIDE: Talent placing the wristband on the participant's non-dominant wrist.
Videographer's Note: Shot 2.3.1 was changed to the talent wearing the sensor himself.
 - 2.3.2. Close-up of strap adjustment demonstrating snug fit with fingertip insertion.

- 2.3.3. Close-up of the underside of the wristband showing sensor contact with skin.
- 2.4. After opening the companion application, connect the wristband via Bluetooth to the smartphone [1]. Verify the pairing status and complete the band setup within the application [2]. Set the location access to 'Always' [3] and toggle on to enable the 'Motion & Fitness' option [4]. **Note: The numbers and narration have been adjusted to account for the added shots.**
- 2.4.1. LAB MEDIA: 2.4.1.mp4. 0:00 – 0:18. *Video Editor: Please blur the text "HUAWEI Band 10-F4A" on the screen capture at 0:01–0:03 timestamp*
Added shot: LAB MEDIA: 2.4.1.mp4. 0:19 – 0:22. Video Editor: Please blur the word "Huawei Health" in the 4th line below the word "Paired".
- 2.4.2. LAB MEDIA: 2.4.2.mp4. 0:00 – 0:04. *Video Editor: Please blur the word "Huawei Health" at all places on the screen capture at timestamp 0:00–0:01.*
Added shot: LAB MEDIA: 2.4.2.mp4. 0:05 – 0:13. Video Editor: Please blur the word "Huawei Health" at all places on the screen capture at timestamp 0:05–0:13.
- 2.5. Monitor the cardiovascular metrics including heart rate, or HR (*H-R*) in beats per minute [1], heart rate variability, or HRV (*H-R-V*) in milliseconds [2], blood pressure, or BP (*B-P*) in millimeters of mercury or mmHg (*M-M-H-G*) [3], electrocardiogram, or ECG (*E-C-G*) in millivolts or mV (*M-V*) [4].
- 2.5.1. LAB MEDIA: 2.5.1.mp4. 0:00 – 0:03. *Video Editor: If possible, highlight the text "95 bpm" on top right and below the date and the Heart rate button below the graph.*
- 2.5.2. LAB MEDIA: 2.5.2.mp4. 0:00 – 0:04. *Video Editor: If possible, highlight the text "—ms" on top and below the date and the HRV button below the graph*
- 2.5.3. LAB MEDIA: 2.5.3.mp4. 0:00 – 0:03. *Video Editor: If possible, highlight the text 123/87 mmHg below the graph*
- 2.5.4. LAB MEDIA: 2.5.4.mp4. 0:00 – 0:05. *Video Editor: Please blur the word "BRT05627" at both places in the screen capture.*
- 2.6. Similarly, monitor the respiratory rate along with other parameters like heart rate and RRI [1]. Under the Health measurements menu, select SpO2 (*S-P-O-two*) to visualize the variations in blood oxygen saturation percentage throughout the day, or over weeks, months, and years [2]. In the Stats menu, choose Active calories to see the movement breakdown and the real-time movement data across daily, weekly, monthly, or yearly trends [3].
- 2.6.1. LAB MEDIA: 2.6.1.mp4. 0:00 – 0:13. *Video Editor: If possible, highlight the text "Respiratory rate" and the value beneath it on top left and below the Heart rate value.*
- 2.6.2. LAB MEDIA: 2.6.2.mp4. 0:00 – 0:05. *Video Editor: In the first 1 second, please*

highlight the option SpO₂ in the panel

- 2.6.3. LAB MEDIA: 2.6.3.mp4. 0:00 – 0:06. *Video Editor: In the first 1 second, please highlight the option “Active calories” under the Stats menu in the panel. Also, please emphasize the “Day”, “Week”, “Month” and “Year” tabs on top when mentioned in the voice over.*
- 2.7. Track the daily, weekly or monthly peripheral skin temperatures in degrees Celsius by selecting the body temperature option under the Health measurements menu [1] and motion data from the accelerometer [2].
- 2.7.1. LAB MEDIA: 2.7.1.mp4. 0:00 – 0:04. *Video Editor: Please emphasize the “Day”, “Week”, “Month” and “Year” tabs on top when mentioned in the voice over.*
- 2.7.2. LAB MEDIA: 2.7.2.mp4. 0:00 – 0:05. *Video Editor: Please emphasize the values and text under “Move breakdown” at the bottom of the screen capture.*
- 2.8. Confirm that all metrics, including motion data, sleep, weight management, cardiovascular, respiratory, and temperature data, along with a summary, are visible [1].
- 2.8.1. LAB MEDIA: 2.8.1.mp4. 0:00 – 0:13
- 2.9. For the environmental sensor setup, connect environmental sensing devices to the portable power bank using appropriate USB (U-S-B) cables for twenty-four-hour operations [1-TXT]. ~~Ensure all connections are stable and cables are securely arranged to prevent accidental disconnection during movement [2].~~
- 2.9.1. WIDE: Talent connecting multiple sensors to a portable power bank. **TXT: Powerbank: 10,000 mAh capacity**
- 2.9.2. ~~Close-up of neatly arranged and secured cables.~~ **Note: The author suggested to delete this shot.**
- 2.10. Place the multi-air-pollutant monitor, noise, and temperature sensors in the fishnet side pocket of the participant’s backpack [1].
- 2.10.1. Talent placing the air pollutant, noise, and temperature sensors in the fish net side pocket of the backpack.
- 2.11. Monitor air-pollution parameters like particulate matters, PM_{2.5} (P-M-two-point-five) values in micrograms per cubic meters [1]. ~~carbon monoxide, or CO (C-O) in parts per million, or ppm (P-P-M) [2], nitrogen dioxide [3], sulfur dioxide [4] and volatile organic compounds, or VOCs (V-O-seas) in parts per billion, or ppb (P-P-B) [5].~~
- 2.11.1. LAB MEDIA: 2.11.1.mp4. 0:00 – 0:25. *Video Editor: The left side of the screen capture shows a series of numbers separated by comma. Please highlight the 2nd column of numbers in the series in all rows and provide a text annotation on the screen with text “PM2.5 concentrations in µg/m³”*
- ~~2.11.2. SCREEN: Show CO values in ppm.~~

~~2.11.3. SCREEN: Show NO₂ values.~~

~~2.11.4. SCREEN: Show SO₂ values.~~

~~2.11.5. SCREEN: Show the value of VOCs in ppb.~~ Note: Author suggested to delete these shots.

2.12. Assess the noise pollution by measuring the live volume levels in decibels, or dB (D-B) [1] and temperature from the temperature sensor in degrees Celsius [2]. Next, attach the light exposure tracker to the shoulder strap facing outward [3] to measure the illuminance in lux or lx (lux) and circadian light A, or CLA (C-L-A) values as 0-1 (zero-to-one) [4].

2.12.1. LAB MEDIA: 2.12.1.mp4. 0:00 – 0:13

2.12.2. SCREEN: Show the temperature in °C. Author's Note: Use the onsite shot.

2.12.3. Talent attaching light tracker on shoulder strap.

2.12.4. SCREEN: Show the illuminance value and CLA values. Author's Note: Use the onsite shot.

2.13. Instruct the participant to carry the backpack during daily activities for twenty-four hours and charge the power bank every night [1]. ~~Provide a contact number for troubleshooting and ensure all sensors are calibrated strictly according to their respective manufacturers' specifications before being handed to the participants [2].~~ Confirm that all sensors are powered on and transmitting real-time environmental data including air particulate matter and formaldehyde concentration [3].

2.13.1. WIDE: Participant wearing backpack and preparing to leave.

~~2.13.2. Close up of talent handing over contact information.~~ Note: The author suggested to delete this shot.

2.13.3. LAB MEDIA: 2.13.3.mp4. 0:04 – 0:25 *Video Editor: The left side of the screen capture shows a series of numbers separated by comma. Please highlight the 1st column of numbers in the series in all rows with yellow color and provide a text annotation on the screen with text "Real-time particle count". Then, highlight the 3rd column with orange color and provide a text annotation with text "Real-time formaldehyde concentration in µg/m³*

2.14. ~~Install the M3-BREATHE (M-three-Breathe) mobile application custom developed for Android and iOS (eye O S) on the participant's smartphone [1].~~ Enable Bluetooth and set location access to always in the menu [2]. Configure the application to record GPS location data at one-minute intervals and sync sensor data every five minutes [3]. In the **Devices** interface, select **End exercise** to complete data synchronization [4].

~~2.14.1. SCREEN: Show installation of the mobile application.~~ Note: Author suggested to delete this shot.

2.14.2. LAB MEDIA: 2.14.2.mp4. 0:00 – 0:10. *Video Editor: Please blur the text "EcTri" at*

both places in the screen capture.

2.14.3. LAB MEDIA: 2.14.3.mp4. 0:02 – 0:09. *Video Editor: Please emphasize flashing of timer with “21:07” and the text “GPS” and signal bars beside it at the top left under the red-colored record symbol.*

2.14.4. LAB MEDIA: 2.14.4.mp4. 0:00 – 0:10. *Video Editor: Please blur the text “BRT05627” on the screen capture and at timestamp 0:09–0:10, blur the text “BRT05627” at both places.*

2.15. In the **Devices** interface, select the **Activity records** to confirm that all daily tracking reminders are set to **On [1]**. Select **Heart rate** option to verify that **Continuous heart rate monitoring** is enabled **[2]**. Under **Emotional Wellbeing**, confirm that **Emotions-stress records** is active, then enable both **notifications** and **cloud data sync.[3]**. Under **Blood Oxygen levels**, verify that the Automatic SpO2 is enabled **[4]**. Review a short test recording to ensure data completeness and accuracy **[5]**, checking for correct time-stamping and plausible values across all streams **[6]**. Record the different modes of daily movements and travel episodes under the **Action Center [7]** along with GPS trajectories **[8]**. **Note: The shot numbers and narration have been adjusted to accommodate the added shots.**

2.15.1. LAB MEDIA: 2.15.1.mp4: 0:00 – 0:02. *Video Editor: Please highlight the text “Activity Records” and emphasize that all options are toggled on.*

Added shot: LAB MEDIA: 2.15.1.mp4. 0:03 – 0:09. Video Editor: Please highlight the text “Heart Rate” and emphasize that “Continuous heart rate monitoring” on top of screen is toggled on

Added shot: LAB MEDIA: 2.15.1.mp4.0:10 – 0:17. Video Editor: Please highlight the text “Emotional wellbeing”

Added shot: LAB MEDIA: 2.15.1.mp4. 0:18 – 0:25. Video Editor: Please highlight the text “Blood oxygen levels” and emphasize that “Automatic SpO₂” on top of screen is toggled on

2.15.2. LAB MEDIA: 2.15.2.mp4. 0:00 – 0:04.

2.15.3. LAB MEDIA: 2.15.3.mp4. 00:05 –0:09 *Video Editor: At 0:08–0:09 timestamp, please blur the text “BRT05627” and “FB:15:1C:A4:7C:F0”*

Added shot: LAB MEDIA: 2.15.4.mp4. 00:00–00:07. Video Editor: Please highlight the text “Bike” and “Walk” in different rows of the screen capture.

Added shot: LAB MEDIA: 2.15.4.mp4. 00:08–00:17. Video Editor: Please highlight the changing day and date at the top of the screen.

3. Data Acquisition, Synchronization and Backup

Demonstrator: Wenbo Guo

- 3.1. Recruit participants using a stratified sampling method to ensure representativeness of the target population [1]. Provide instructional materials to the participants including manuals and videos for device usage [2]. Conduct a baseline health survey within the application to collect demographic and medical information [3].
- 3.1.1. ~~WIDE: Research team interacting with participants during recruitment.~~ **Note: The author suggested deleting this shot.**
- 3.1.2. Close-up of participant reviewing instructional materials.
- 3.1.3. ~~SCREEN: Display survey form being completed within the application.~~ **Note: The author suggested deleting this shot.**
- 3.2. Assess the demographic data parameters like gender, age, weight, height and marital status of the participants [1]. Evaluate medical history including non-communicable diseases, or NCDs (*N-C-dees*) [2] and respiratory health status such as smoking pack-years, chronic cough, or dyspnea [3]. Additionally, assess self-reported health data such as physical and mental well-being, alcohol consumption, diet, physical activity, and sleep quality [4].
- 3.2.1. LAB MEDIA: 3.2.1.mp4. 0:00 – 0:04. *Video Editor: Please blur the ECTRI logo beside demo at timestamp 0:00–0:01 and beside Avatar at timestamp 0:02–0:04*
- 3.2.2. ~~SCREEN: Show the medical history field including the NCDs sub field in the survey form.~~
- 3.2.3. ~~SCREEN: Show the respiratory health status field showing sub fields like smoking pack years, chronic cough etc.~~
- 3.2.4. ~~SCREEN: Show the self-reported health information page with parameters like physical and mental well-being, alcohol consumption, diet, physical activity and sleep quality.~~ **Note: The author suggested deleting 3.2.2, 3.2.3, and 3.2.4**
- 3.3. Instruct the participant to wear physiological sensors and carry environmental devices continuously for 24 hours [1]. During sleep, position the environmental sensors to maintain exposure assessment, with particular attention to the light sensor orientation. [2]. Remind the participant to recharge the power bank daily to maintain uninterrupted operation and data [3].
- 3.3.1. WIDE: Participant wearing devices during daily routine.
- 3.3.2. ~~Medium shot of sensors placed in bedroom environment.~~ **Note: The author suggested to delete this shot.**
- 3.3.3. Close-up of participant connecting power bank to charger.
- 3.4. Monitor the data stream through manual checks or via automated backend alerts [1]. Contact the participant if disconnection exceeds 30 minutes [2]. Under the Calorie records, enter the diet log for different meals, including breakfast, lunch, dinner, or an extra meal [3].

3.4.1. LAB MEDIA: 3.4.1.mp4. 0:00 – 0:07

~~3.4.2. Medium shot of researcher making a phone call to participant.~~ Note: The author suggested deleting this shot.

3.4.3. LAB MEDIA: 3.4.3.mp4. 0:00 – 0:13

~~3.5. Sync all collected real time and activity travel diary data to a secure cloud server configured with regular automated backups via network connection [1]. Store data temporarily on the smartphone's internal memory [2] and clear the synced data from the device every day after successful verification by the cloud server [3]. Ensure all data are anonymized and securely stored according to institutional data security and privacy policies [4].~~

~~3.5.1. SCREEN: Show data syncing process to cloud server.~~

~~3.5.2. SCREEN: Display showing data stored in phone's internal memory.~~

~~3.5.3. SCREEN: Data clearing from smartphone storage and syncing to the cloud server.~~

~~3.5.4. Medium shot of researcher reviewing secure data storage system.~~ Note: The author suggested deleting these shots.

Results

4. Results

- 4.1. Average PM_{2.5} concentrations and subjective well-being or SWB (*S-W-B*) scores varied significantly across daily activities, with exposure differing markedly between indoor versus outdoor and sedentary versus active settings [1]. The highest average exposure exceeding 20 micrograms per cubic meter was observed during sleep, surfing the internet, entertainment, studying and taking a walk [2].
 - 4.1.1. LAB MEDIA: Figure 1: *Video editor: Please emphasize the X-axis and all the blue bars.*
 - 4.1.2. LAB MEDIA: Figure 1: *Video editor: Please emphasize the blue bars labelled "Sleep", "Surfing the Internet", "Entertainment", "Study" and "Taking a Walk".*
- 4.2. Mid-range exposure concentrations in the range of fifteen to twenty micrograms per cubic meter were found for activities such as work, physical activity, caregiving and trips [1]. The lowest exposures in the range of five to fifteen micrograms per cubic meter were recorded during personal affairs, seeing a doctor, dining and personal care [2].
 - 4.2.1. LAB MEDIA: Figure 1: *Video editor: Please emphasize the blue bars labelled "Work", "Physical Activity", "Taking care of someone" and "Trips".*
 - 4.2.2. LAB MEDIA: Figure 1: *Video editor: Please emphasize the blue bars labelled "Personal affairs", "Seeing a doctor", "Dining", "Personal care".*
- 4.3. The cognitive SWB scores showed less variability across activities, ranging narrowly between one-point seven and two-point three on a one-to five dissatisfaction scale [1]. The lowest satisfaction scores were associated with seeing a doctor, trips, personal affairs and work [2].
 - 4.3.1. LAB MEDIA: Figure 1: *Video editor: Please emphasize the Y-axis and the brown line.*
 - 4.3.2. LAB MEDIA: Figure 1: *Video editor: Please emphasize the points on the brown line corresponding to "Seeing a doctor", "Trips", "Personal affairs" and "Work".*
- 4.4. The highest satisfaction scores were linked to physical activity, entertainment and social activity [1]. The activity types associated with higher PM_{2.5} exposure concentrations did not always correspond to lower cognitive SWB, suggesting decoupling patterns between PM_{2.5} exposure and self-reported cognitive SWB [2].
 - 4.4.1. LAB MEDIA: Figure 1: *Video editor: Please emphasize the points on the brown line corresponding to "Physical activity", "Entertainment", and "Social activity".*
 - 4.4.2. LAB MEDIA: Figure 1: *Video editor: Please emphasize the X-axis and blue bars and Y-axis and the brown line sequentially.*

Pronunciation Guide:

1. Physiological
Pronunciation link: <https://www.merriam-webster.com/dictionary/physiological>
IPA: /ˌfɪz.i.əˈlɑː.dʒɪ.kəl/
Phonetic Spelling: fiz·ee·uh·laa·ji·kuhl
2. Multimodal
Pronunciation link: <https://www.merriam-webster.com/dictionary/multimodal>
IPA: /ˌmʌl.tiˈmoʊ.dəl/
Phonetic Spelling: muhl·tee·moh·duhl
3. Synchronization
Pronunciation link: <https://www.merriam-webster.com/dictionary/synchronization>
IPA: /ˌsɪŋ.krə.nəˈzeɪ.jən/
Phonetic Spelling: sing·kruh·nuh·zay·shuhn
4. Cardiovascular
Pronunciation link: <https://www.merriam-webster.com/dictionary/cardiovascular>
IPA: /ˌkɑːr.di.ʊsˈvæs.kjə.lə/
Phonetic Spelling: kar·dee·oh·vas·kyuh·luhr
5. Variability
Pronunciation link: <https://www.merriam-webster.com/dictionary/variability>
IPA: /ˌver.i.əˈbɪl.ə.ti/
Phonetic Spelling: vair·ee·uh·bil·uh·tee
6. Electrocardiogram
Pronunciation link: <https://www.merriam-webster.com/dictionary/electrocardiogram>
IPA: /ɪˌlek.troʊˈkɑːr.di.ʊsˌgræm/
Phonetic Spelling: ih·lek·troh·kar·dee·oh·gram
7. Respiratory
Pronunciation link: <https://www.merriam-webster.com/dictionary/respiratory>
IPA: /ˈres.pə.əˌtɔːr.i/, /rɪˈspɪr.əˌtɔːr.i/
Phonetic Spelling: res·puh·ruh·tor·ee
8. Photoplethysmography
Pronunciation link: <https://www.merriam-webster.com/dictionary/photoplethysmography>
IPA: /ˌfoʊ.təʊ.pleθ.ɪzˈmɑː.grə.fi/
Phonetic Spelling: foh·toh·pleth·iz·maa·gruh·fee
9. Proximal
Pronunciation link: <https://www.merriam-webster.com/dictionary/proximal>
IPA: /ˈprɑːk.sə.məl/
Phonetic Spelling: prok·suh·muhl

10. Ulnar
Pronunciation link: <https://www.merriam-webster.com/dictionary/ulnar>
IPA: /'ʌl.nə/
Phonetic Spelling: uhl·nuhr
11. Styloid
Pronunciation link: <https://www.merriam-webster.com/dictionary/styloid>
IPA: /'stɑɪ.lɔɪd/
Phonetic Spelling: sty·loyd
12. Peripheral
Pronunciation link: <https://www.merriam-webster.com/dictionary/peripheral>
IPA: /pə'rɪf.ə.əl/
Phonetic Spelling: puh·rif·uh·ruhl
13. Accelerometer
Pronunciation link: <https://www.merriam-webster.com/dictionary/accelerometer>
IPA: /ək.səl.ə'rɑː.mə.tə/
Phonetic Spelling: ak·sel·uh·raa·muh·tuhr
14. Particulate
Pronunciation link: <https://www.merriam-webster.com/dictionary/particulate>
IPA: /pɑːr'tɪk.jə.lət/
Phonetic Spelling: par·tik·yuh·luht
15. Micrograms
Pronunciation link: <https://www.merriam-webster.com/dictionary/microgram>
IPA: /'maɪ.kroʊ.græm/
Phonetic Spelling: my·kroh·gram
16. Nitrogen
Pronunciation link: <https://www.merriam-webster.com/dictionary/nitrogen>
IPA: /'naɪ.trədʒən/
Phonetic Spelling: ny·truh·juhn
17. Sulfur
Pronunciation link: <https://www.merriam-webster.com/dictionary/sulfur>
IPA: /'sʌl.fə/
Phonetic Spelling: sul·fuhr
18. Volatile
Pronunciation link: <https://www.merriam-webster.com/dictionary/volatile>
IPA: /'vɑː.lə.təl/, /'vɑː.lə.tal/
Phonetic Spelling: vah·luh·tuhl
19. Illuminance
Pronunciation link: <https://www.merriam-webster.com/dictionary/illuminance>

IPA: /ɪˈluː.mə.nəns/

Phonetic Spelling: ih·loo·muh·nuhns

20. Circadian

Pronunciation link: <https://www.merriam-webster.com/dictionary/circadian>

IPA: /səˈkeɪ.di.ən/

Phonetic Spelling: sur·kay·dee·uhn

21. Calibrated

Pronunciation link: <https://www.merriam-webster.com/dictionary/calibrate>

IPA: /ˈkæl.əˌbreɪt/

Phonetic Spelling: kal·uh·brayt

22. Trajectories

Pronunciation link: <https://www.merriam-webster.com/dictionary/trajectory>

IPA: /trəˈdʒek.tə.i/

Phonetic Spelling: truh·jek·tuh·ree

23. Stratified

Pronunciation link: <https://www.merriam-webster.com/dictionary/stratified>

IPA: /ˈstræt.əˌfaɪd/

Phonetic Spelling: strat·uh·fyd

24. Representativeness

Pronunciation link: <https://www.merriam-webster.com/dictionary/representativeness>

IPA: /ˌrep.rɪˈzen.tə.tɪv.nəs/

Phonetic Spelling: rep·ruh·zen·tuh·tiv·nuhs

25. Dyspnea

Pronunciation link: <https://www.merriam-webster.com/dictionary/dyspnea>

IPA: /dɪspˈniː.ə/, /dɪsˈniː.ə/

Phonetic Spelling: disp·nee·uh

26. Anonymized

Pronunciation link: <https://www.merriam-webster.com/dictionary/anonymize>

IPA: /əˈnɑː.nəˌmaɪz/

Phonetic Spelling: uh·non·uh·myz

27. Demographic

Pronunciation link: <https://www.merriam-webster.com/dictionary/demographic>

IPA: /ˌdem.əˈgræf.ɪk/

Phonetic Spelling: dem·uh·graf·ik

28. Formaldehyde

Pronunciation link: <https://www.merriam-webster.com/dictionary/formaldehyde>

IPA: /fɔːrˈmæl.dəˌhaɪd/

Phonetic Spelling: for·mal·duh·hyde

