Phonetics
Speech involves the production of an airflow, typically from the lungs, which gets obstructed in various ways in the vocal tract.
One way of categorizing the obstructions to the airflow in the vocal tract is by **place of articulation**.
**Bilabial:** both lips.

[p] paint
[b] bath
[m] math
[w] wipe
**Labiodental**: top teeth and lower lip.

[f]  face
[v]  vase
**Interdental:** tongue between the teeth.

[θ] **thistle**  
[ð] **this**
**Alveolar**: tongue tip against the alveolar ridge, just behind the top teeth.

\[
\begin{align*}
[t] & \quad \text{teeth} \\
[d] & \quad \text{duck} \\
[s] & \quad \text{sail} \\
[z] & \quad \text{zoom} \\
[n] & \quad \text{nail}
\end{align*}
\]
**Alveopalatal**: tongue blade slightly behind the alveolar ridge (also called "postalveolar").

\[
\begin{align*}
\text{[ʃ]} & \quad \text{ship} \\
\text{[ʒ]} & \quad \text{azure}
\end{align*}
\]
**Palatal:** even further behind the alveolar ridge, back where the roof of the mouth reaches its height.

[j]  year
**Velar**: tongue body against the velum, the soft tissue at the back of the mouth.

[k] *kernel, caught*

[g] *gone*

[ŋ] *sing*
**Glottal:** the glottis (vocal cords).

[ʔ]  _uh-_uh ("no")
[h]  help
But place of articulation isn't the whole story, as we’ve already seen.

What distinguishes [s] from [z], or [θ] from [ð], or [t] from [d]?

...Voicing: vocal cords can either vibrate or not.

[s], [z], [t], and [d] are all **alveolar**, but [s] and [t] are **voiceless** and [z] and [d] are **voiced**.
So if [s] and [t] are both voiceless alveolars, what distinguishes [s] from [t]? or [d] from [z]?

...**Manner of Articulation**: [t] is a **stop** (or a **plosive**), and [s] is a **fricative**.
[t], [d]: airflow stopped

[s], [z]: airflow restricted, but not stopped
- **place, manner, voicing:**

<table>
<thead>
<tr>
<th>Place</th>
<th>Stop</th>
<th>Fricative</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>[b], [p]</td>
<td></td>
</tr>
<tr>
<td>labiodental</td>
<td></td>
<td>[v], [f]</td>
</tr>
<tr>
<td>interdental</td>
<td></td>
<td>[ð], [θ]</td>
</tr>
<tr>
<td>alveolar</td>
<td>[d], [t]</td>
<td>[z], [s]</td>
</tr>
<tr>
<td>alveopalatal</td>
<td></td>
<td>[ʃ], [ʒ]</td>
</tr>
<tr>
<td>palatal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>velar</td>
<td>[g], [k]</td>
<td></td>
</tr>
<tr>
<td>glottal</td>
<td>[ʔ]</td>
<td>[h]</td>
</tr>
</tbody>
</table>
So if [d] is a voiced alveolar stop, and [z] is a voiced alveolar fricative, then what's [n]? It's voiced, and a stop...

...and it's nasal.
[t], [d]: airflow stopped (at the alveolar ridge)  

[n]: no flow through mouth, but lowered velum allows air to flow through nose
<table>
<thead>
<tr>
<th></th>
<th>stop</th>
<th>fricative</th>
<th>nasal (stop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>[b], [p]</td>
<td>[v], [f]</td>
<td>[m]</td>
</tr>
<tr>
<td>labiodental</td>
<td></td>
<td>[θ], [ð]</td>
<td></td>
</tr>
<tr>
<td>interdental</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alveolar</td>
<td>[d], [t]</td>
<td>[z], [s]</td>
<td>[n]</td>
</tr>
<tr>
<td>alveopalatal</td>
<td></td>
<td>[ʒ], [ʃ]</td>
<td></td>
</tr>
<tr>
<td>palatal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>velar</td>
<td>[g], [k]</td>
<td></td>
<td>[ŋ]</td>
</tr>
<tr>
<td>glottal</td>
<td>[ʔ]</td>
<td></td>
<td>[h]</td>
</tr>
</tbody>
</table>

(voiceless, voiced)
This way of classifying the sounds leads us to wonder about gaps:

<table>
<thead>
<tr>
<th></th>
<th>stop</th>
<th>fricative</th>
<th>nasal (stop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>[p], [b]</td>
<td>[?] , [?]</td>
<td>[m], [?]</td>
</tr>
<tr>
<td>labiodental</td>
<td>[f], [v]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interdental</td>
<td>[θ], [ð]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alveolar</td>
<td>[t], [d]</td>
<td>[s], [z]</td>
<td>[n]</td>
</tr>
<tr>
<td>alveopalatal</td>
<td>[ʃ], [ʒ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>palatal</td>
<td>[ʔ], [ʔ]</td>
<td>[ʔ], [ʔ]</td>
<td>[ʔ]</td>
</tr>
<tr>
<td>velar</td>
<td>[k], [g]</td>
<td>[ʔ], [ʔ]</td>
<td>[ŋ]</td>
</tr>
<tr>
<td>glottal</td>
<td>[ʔ]</td>
<td>[h]</td>
<td>[ʔ]</td>
</tr>
</tbody>
</table>
some of the gaps:

<table>
<thead>
<tr>
<th></th>
<th>stop</th>
<th>fricative</th>
<th>nasal (stop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>[p], [b]</td>
<td>[φ], [β]</td>
<td>[m], [m̥]</td>
</tr>
<tr>
<td>labiodental</td>
<td></td>
<td>[f], [v]</td>
<td></td>
</tr>
<tr>
<td>(inter)dental</td>
<td>[t̪], [d̪]</td>
<td>[θ], [ð]</td>
<td></td>
</tr>
<tr>
<td>alveolar</td>
<td>[t], [d]</td>
<td>[s], [z]</td>
<td>[n]</td>
</tr>
<tr>
<td>alveopalatal</td>
<td>[ʃ], [ʒ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>palatal</td>
<td>[c], [ɟ]</td>
<td>[ç], [j]</td>
<td>[ɲ] ([ɲ])</td>
</tr>
<tr>
<td>velar</td>
<td>[k], [g]</td>
<td>[x], [ɣ]</td>
<td>[ŋ]</td>
</tr>
<tr>
<td>glottal</td>
<td>[ʔ]</td>
<td>[h]</td>
<td>[ʔ]</td>
</tr>
</tbody>
</table>
some other gaps:

**retroflex**: tongue tip
on palate: [t] [d] [s] [z] [n]

**uvular**: tongue body
touches near uvula: [q] [ɡ] [χ] [ʁ] [n]
pharyngeal: constriction near pharyngeal wall:

\[ [h] \ [ʃ] \] (fricatives)
<table>
<thead>
<tr>
<th>Category</th>
<th>Sounds</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bilabial</td>
<td>[p], [b]</td>
<td>stop</td>
</tr>
<tr>
<td>fricative</td>
<td>[φ], [β]</td>
<td></td>
</tr>
<tr>
<td>nasal (stop)</td>
<td>[m], [m̥]</td>
<td></td>
</tr>
<tr>
<td>labiodental</td>
<td>[t̪], [d̪]</td>
<td>(inter)dental</td>
</tr>
<tr>
<td>fricative</td>
<td>[f], [v]</td>
<td></td>
</tr>
<tr>
<td>alveolar</td>
<td>[t], [d]</td>
<td>alveolar</td>
</tr>
<tr>
<td>fricative</td>
<td>[s], [z]</td>
<td></td>
</tr>
<tr>
<td>alveopalatal</td>
<td>[ʃ], [ʒ]</td>
<td>alveopalatal</td>
</tr>
<tr>
<td>fricative</td>
<td>[ʂ], [ʐ]</td>
<td></td>
</tr>
<tr>
<td>retroflex</td>
<td>[t̪], [d̪]</td>
<td>retroflex</td>
</tr>
<tr>
<td>fricative</td>
<td>[ʃ], [ʒ]</td>
<td></td>
</tr>
<tr>
<td>palatal</td>
<td>[c], [ɟ]</td>
<td>palatal</td>
</tr>
<tr>
<td>fricative</td>
<td>[ç], [ʝ]</td>
<td></td>
</tr>
<tr>
<td>palatal ([ñ])</td>
<td>[n]</td>
<td>([ñ])</td>
</tr>
<tr>
<td>velar</td>
<td>[k], [g]</td>
<td>velar</td>
</tr>
<tr>
<td>fricative</td>
<td>[x], [ɣ]</td>
<td></td>
</tr>
<tr>
<td>uvular</td>
<td>[q], [ɢ]</td>
<td>uvular</td>
</tr>
<tr>
<td>fricative</td>
<td>[χ], [ʁ]</td>
<td></td>
</tr>
<tr>
<td>pharyngeal</td>
<td>[ʔ]</td>
<td>pharyngeal</td>
</tr>
<tr>
<td>fricative</td>
<td>[χ], [ʁ]</td>
<td></td>
</tr>
<tr>
<td>glottal</td>
<td>[ʔ]</td>
<td>glottal</td>
</tr>
<tr>
<td>fricative</td>
<td>[h]</td>
<td></td>
</tr>
</tbody>
</table>
some neglected manners of articulation:

**Approximants:** tongue gestures briefly at another articulatory point, without making contact:

- \textit{w} [w], \textit{y} [j], \textit{l} [l], \textit{r} [ɹ] (sometimes written [r], which we'll use)

These are sometimes divided into \textbf{glides} ([w], [j])
and \textbf{liquids} ([l], [r])

**Affricates:** like a stop immediately followed by a fricative

- \textit{ch} [tʃ], \textit{j} [dʒ]
<table>
<thead>
<tr>
<th>Region</th>
<th>Stop</th>
<th>Fricative</th>
<th>Nasal</th>
<th>Glide Liquid Affr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilabial</td>
<td>[p], [b]</td>
<td>[φ], [β]</td>
<td>[m], [m̥]</td>
<td>[w]</td>
</tr>
<tr>
<td>Labiodental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interdental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alveolar</td>
<td>[t], [d]</td>
<td>[s], [z]</td>
<td>[n]</td>
<td></td>
</tr>
<tr>
<td>Alveopalatal</td>
<td></td>
<td></td>
<td></td>
<td>[l]</td>
</tr>
<tr>
<td>Retroflex</td>
<td>[t], [d]</td>
<td>[s], [z]</td>
<td>[n]</td>
<td>[r]</td>
</tr>
<tr>
<td>Palatal</td>
<td>[c], [ɟ]</td>
<td>[ç], [j]</td>
<td>[ɲ] ([ɲ])</td>
<td>[j]</td>
</tr>
<tr>
<td>Velar</td>
<td>[k], [g]</td>
<td>[x], [ɣ]</td>
<td>[ŋ]</td>
<td>[w]</td>
</tr>
<tr>
<td>Uvular</td>
<td>[q], [ɢ]</td>
<td>[ç], [ʝ]</td>
<td>[ɲ]</td>
<td></td>
</tr>
<tr>
<td>Pharynggeal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glottal</td>
<td>[ʔ]</td>
<td>[h]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

...not that this exhausts the range of possible speech sounds (linguo-labial stops! ejectives! clicks! voiceless liquids!), but it'll do for now...
Time to go through the vowels systematically.

compare:   [i]    bead
           [æ]    bad
in fact:    [i]   heat   High
            [e]   hate   Mid
            [æ]   hat    Low
Now compare:

[i] he [u] who
<table>
<thead>
<tr>
<th>Region</th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>[i]</td>
<td>[u]</td>
</tr>
<tr>
<td>Mid</td>
<td>[e]</td>
<td>[o]</td>
</tr>
<tr>
<td>Low</td>
<td>[æ]</td>
<td>[æ]</td>
</tr>
</tbody>
</table>

- He'd
- Who'd
- Hate
- Hoed
- Had
- Hot
<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th></th>
<th>Back</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>[ɪ]</td>
<td>he'd</td>
<td>[u]</td>
<td>who'd</td>
</tr>
<tr>
<td>Mid</td>
<td>[ɛ]</td>
<td>hate</td>
<td>[o]</td>
<td>hoed</td>
</tr>
<tr>
<td>Low</td>
<td>[æ]</td>
<td>had</td>
<td>[a]</td>
<td>hot</td>
</tr>
</tbody>
</table>
What's the difference between...

[u] (who'd) and [ʊ] (hood)?
[i] (he'd) and [ɪ] (hid)?
[e] (raid) and [ɛ] (red)?
[o] (coat) and [ɔ] (caught)?

tense vs. lax; no English monosyllables end in lax vowels that are either front or high...
[fli], [flu], [fle], *[flɪ], *[flʊ], *[fle]
High  
\[\text{Front}\]  
[i] he'd,  
[ɨ] hid

Mid  
[e] hate,  
[ɛ] head

Low  
[æ] had

tense, lax

Back  
[u] who'd,  
[o] hood

[о] hoed,  
[ɔ] hawed

[a] hot

Not all English dialects have all of these vowels.
How do you say **caught** and **cot**?

And not all English dialects have these in the same distribution.  
**Mary, merry, marry**
one more pair of vowels:

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>[i]</td>
<td>[u]</td>
</tr>
<tr>
<td></td>
<td>he'd,</td>
<td>who'd,</td>
</tr>
<tr>
<td></td>
<td>[ɪ] hid</td>
<td>[ʊ] hood</td>
</tr>
</tbody>
</table>

| Mid   | [e]    | [ə] machine|
|       | hate,  | [o] hoed,   |
|       | [ɛ] head| [ɔ] hawed   |

| Low   | [æ]    | [ə] hot    |
|       | had    |            |
|       | tense, lax |    |

Not all speakers distinguish between [ə] and [ʌ].
"above" = əbʌv
English has (about) 14 vowels, and 5 letters to spell them with...
Reading practice:

ʃi sɛlz si şɛlz

su sɛz hiz ě bæd ēg

ē mæn, ě plæn, ě kənæl, pænəmə

tap tʃapstɪk ʃaps stak tap tʃapstɪks
<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Central</th>
<th>Back [rounded]</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>[i] he'd,</td>
<td>[u] who'd,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ɪ] hid</td>
<td>[ʊ] hood</td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td>[e] hate,</td>
<td>[ə] machine</td>
<td>[o] hoed,</td>
</tr>
<tr>
<td></td>
<td>[ɛ] head</td>
<td>[ʌ] dove</td>
<td>[ɔ] hawed</td>
</tr>
<tr>
<td>Low</td>
<td>[æ] had</td>
<td>[ɑ] hot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plus diphthongs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(and several English tense vowels are sort of diphthongal:</td>
<td>[e]=[ej], [o]=[ow])</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[e]=[ej], [o]=[ow])</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Again, this categorization has (at least) two benefits:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• leads us to look for gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• helps with theories of sound change</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front</td>
<td>Central</td>
<td>Back</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>High</td>
<td>[i] he'd, [ɪ] hid</td>
<td>[u] who'd, [ʊ] hood</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>[æ] had</td>
<td></td>
<td>[ɑ] hot</td>
</tr>
</tbody>
</table>

In English, all and only nonlow back vowels are rounded.

But is that necessary?
High  [i]  he'd,  [ɪ]  hid  [u]  who'd,  [ʊ]  hood


Low  [æ]  had  [ɑ]  hot

[y],  German Gefühl 'feeling'
(high front rounded vowel)

[w],  Korean [kunɛ] 'swing'
(high back unrounded vowel)
<table>
<thead>
<tr>
<th>Level</th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
<th>Rounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>[i] he'd,</td>
<td>[u] who'd,</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ɪ] hid</td>
<td>[ʊ] hood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td>[ɛ] hate,</td>
<td>[ɔ] machine</td>
<td>[o] hoed,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ɛ] head</td>
<td>[ʌ] dove</td>
<td>[ɔ] hawed</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>[æ] had</td>
<td>[ɑ] hot</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[y], German Gefühl 'feeling'  
(high front rounded vowel)

[u], Korean [kunɛ] 'swing'  
(high back unrounded vowel)

[ɛ], French [mɛ], 'hand' (vs. [mɛ] 'dish')  
(front mid lax nasalized vowel)
other ways to manipulate airflow
• ejectives
• clicks
• implosives

(…and others)