

**Electrochemical Translation: The Continued Relevance of Loewi's Experiments**

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## The Discovery of Acetylcholine

The discovery of acetylcholine is not significant just for acetylcholine, but instead for proving that neurons speak. The early 1900's saw many scientists convinced of the reticular theory—that neurons did not need to communicate at all. Nerves create a dense web of outstretched axons and dendrites that seem to leave no gaps from neuron to neuron, building one continuous path of exchange. This was disproven by the staining of singular, individual neurons done by Santiago Ramón y Cajal which demonstrated that each cell ends (Valenstein, 2005). They stand alone. The gap between neurons—the synapse—is so minuscule that it allowed the rise of said theory that neurons create a unified web. As infinitesimal as it is that gap still needs to be bridged, but what by?

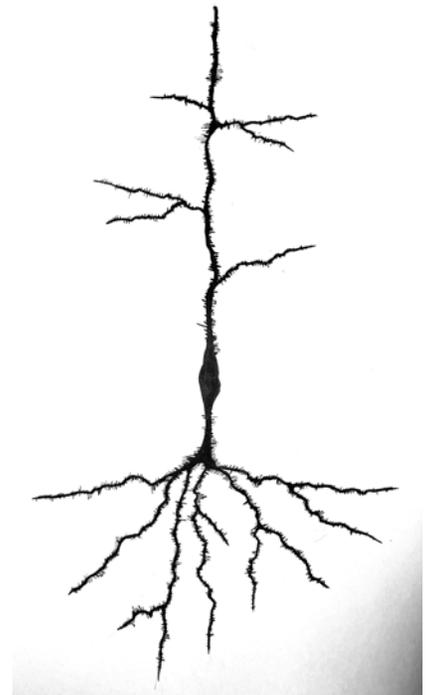


Figure 1: A Neuron Alone

We knew that our brains are paved in electricity: the differences in charge (ions) are motivated to flow and equalize. My mother told me that. She speaks Bangla, but attended English-medium school, so she explains the brain in my tongue (Rasheed, 2023). Within a neuron—every neuron—stimuli must cause an electrical shift, an influx of positive ions into the normally negative cell, and that current is propagated down the axon (its long, outstretched arm) so the neuron can ‘think’ or process information (Bear et al., 2016). When passing that feeling to the next neuron in line, why wouldn't the cell continue to use an electrical signal? Why not send ions forth into the gap, when there is such unity in cells keeping to one language? Why should we question it?

Some did. In spite of peers' affirmations, chemist Otto Loewi dreamt that nerves did not fall exclusively in the realm of the electricians. By pithing a frog, you can keep its heart beating

outside its body (Murray, 2019), so he carved out said heart and settled it in a bath of water. He then electrically stimulated the still-connected vagus nerve to slow the pulse. It beat softer. What this frog heart did not know, was that after its removal, cold and dripping from the brine, a second frog heart was laid to rest here. It had no help—no vagus nerve connected to it (he had two frog hearts. I wonder if they loved each other. do you think they were mother and daughter? or lovers? or sisters?) nor electric hand to hold—and yet it beat *slowly*. Something left in the water was calming the pulse in the second heart, whispering আমি শুনছি তোমাকে, তুমি শুনছো? তুমি আমার কলিজা. The first *I can hear you, can you hear me? You are my heart.* nerve had left something, solid and tangible, held hovering in the water like breath not yet taken, that told the second heart—

I don't know that people eat frog hearts the way we eat the legs,

(teeth repeating *do not soar, do not flee*)

but I wonder if there was temptation? To hold it between his jaws as he dipped it in the brine and

in tandem with the ~~water~~ *acetylcholine*

commanded the second heart—

—to rest.

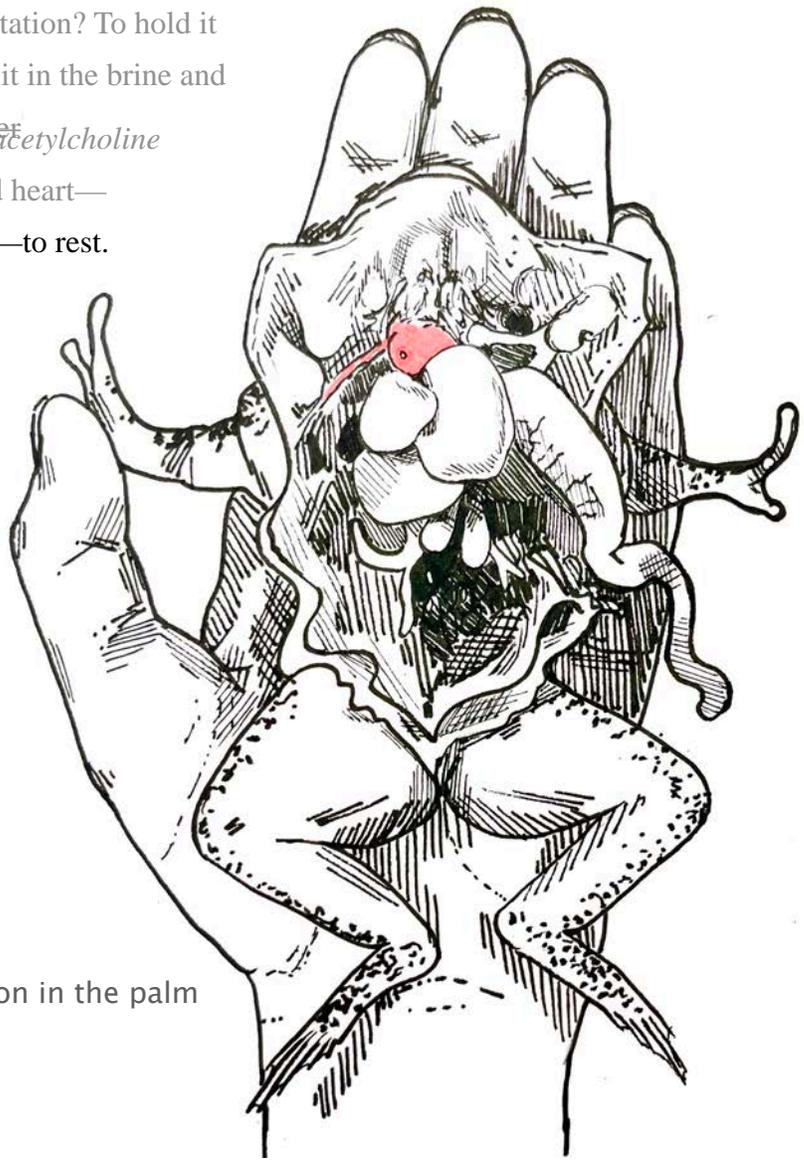


Figure 2: Frog dissection in the palm

### Electrochemical Translation

We know about neurotransmitters now—adrenaline in fear, norepinephrine in rest,  
 (it's not just them. and it's not about the amount  
 lack of dopamine and serotonin in depression. you have hoarded in your brain but the amount  
 you can use. we already have joy stored in our  
 body, Maa, but we don't know how to free it.)  
 Loewi sampled his brine and discovered the first  
 neurotransmitter: acetylcholine. This established that, at least between the vagus nerve and the  
 muscles of the heart, communication was not electrical—the neuron has to speak in a new  
 tongue. The name of the game is translating the electric feeling to the chemical word. We see the  
 synapse:



Figure 3: Here's the Big Fuss

(1) The towering stem of the axon. Thrumming with power as an action potential  
 (a monsoon flood of sodium(+)) surging inside the cell)  
 courses through the pre-synaptic neuron. Rushing towards its own language barrier.

(2) The synaptic cleft. A yawning maw between each neuron, insurmountable to cross, and stretching an impossible 0.2 micrometers.

(3) The neurotransmitter.

(Take your pick.)

(Or really take what you can cling to.)

A neurotransmitter is a microscopic signaling molecule meant to wade through the cleft. They're held in locked rooms at the ends of each axon, waiting for the action potential to give them reason to *fling yourself off the ship and flee*. *Swim as far as you can. Tell the next neuron what we saw.*

There are hundreds of neurotransmitters (—dopamine, glycine, GABA, norepinephrine, English, nitric oxide, oxytocin, ATP, Bangla, glutamate, Croatian, histamine, vasopressin—) but each neuron cannot hold them all. Many are perpetually speaking to cells of different mother tongues. (Encyclopædia Britannica, 2023). For instance:

If I, a cell, am full of potential

full of *I miss you, I love you, where are you, are you well?*

I will say: Maa, you look tired.

If she, a cell, is full of potential

full of *I miss you, I love you, where are you, are you well?*

She will say: বেশী বেশী খাও.  
*Eat more*

(4) The transmitter's receptor. *I can hear you, I can hear you, I can hear—*

(5) The post-synaptic neuron—well now you've heard. What would you like it to **mean**?

We speak the same every moment, every mile, every stretch of axon, dendrite, we speak the same until the last moment of release when we actually *say*.

The shape of this story is translating—every thought you have is the process of million of translations occurring. Worse still, one neurotransmitter’s release, one conversation, one word, is almost certainly not enough. A single signal rarely inspires the next action potential alone, so translation gets *harder* every time; we need multiplicity and volume and screams.

Many action potentials are lost in translation

Not enough power to be known to the next in line

So translation is not just *my* burden when I stop just under the lip of truly understanding Bangla,

Unable to swim that 0.2  $\mu$ m to speaking it.

Instead, it is ~~human~~ vertebrate animal<sup>1</sup> nature.

Even neurons speaking the same tongue must translate their feelings into words, hoping for correctness and victory and love.

### Translations

Electrical: My mother meant *I love you, I need you to thrive*

Chemical: My mother said *you will never amount to anything with your bleeding heart*

Electrical: I meant *I love you, I owe you so much, and I cannot escape the guilt when I am around you so much that I cannot stand to be here*

Chemical: I said *Anyway, I’m going upstairs*

Electrical: My mother meant *I love you, I worry, your health is so important to me please*

Chemical: My mother said *You are aging so much worse than our peers, Sohel, you’re so skinny your bones stick out of your skin, you don’t even look like the man I married anymore*

When I ask my father: *are you ever just*

*(so, so so, down to your bones and gristle and rot and I think I am bathing in acetylcholine because it is all becoming so slow, I am moving through syrup and slurry, and soon my body will give up, so, so, so) sad?*

Chemical: He says *it’s because you don’t exercise enough*

Electrical: He means *please don’t grow where I cannot save you. please don’t take my problems too soon<sup>2</sup>.*

~~(I hope)~~ He means *I love you.* ~~(He’s never said that in Bangla either)~~

<sup>1</sup> save for sea sponges, spared a nervous system at all.

<sup>2</sup> it will always be too soon.

## বেশী বেশী খাও

Loewi used the vagus nerve in his experiment. We have that. Press two fingers into your throat and nestle them underneath your jaw, you will feel your heart beating through your carotid arteries *lub dub, lub dub*, careful not to smudge your dissection lines. The vagus nerve runs along that artery, known for its role in the parasympathetic nervous system. The vagus nerve asks of you to *rest* and *digest* because you are *safe* (Encyclopædia Britannica, 2023).

Maa hands me a plate of fruit, lovingly cleaved. I bring it to my teeth.

—the frog’s heart rends on my incisors, pink froth spilling from the  
corners of my lips, tendons and troponin flooding onto my  
tongue with the acrid

taste of bile and formaldehyde

as if it can begin digesting me back,

and the scent on my hands

brush-brushing my lips

is all sweat on metal

from holding the scalpel—

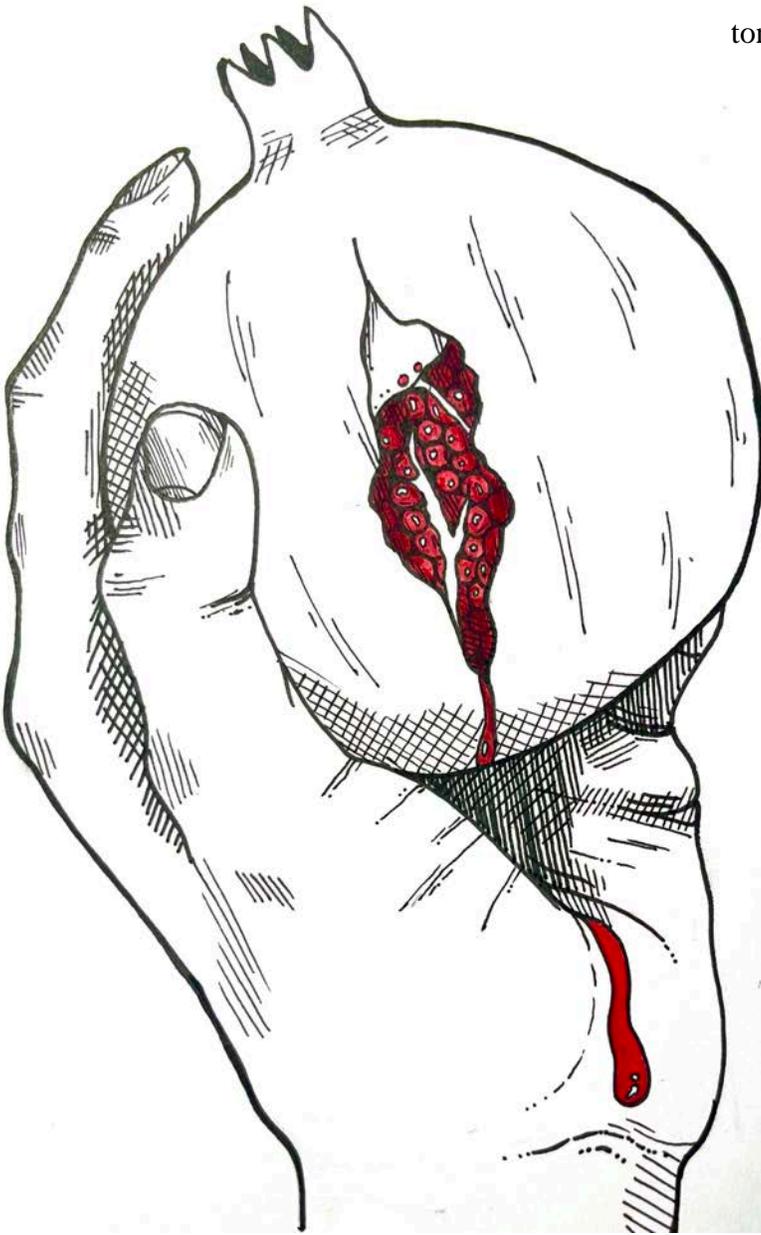


Figure 4: Dissection.  
Cleaving the fruit  
to (painstakingly) serve

My mother said: মামনি তুমি আমার কলিজার টুকরা. Which means *you are a piece of my heart*, but when you cook ‘হৃদয়’ becomes the word for liver, organ meat. And it is always sweet, and *heart* always lovely, and I always laugh telling her *Oh, I am a piece of your liver!*

And she smiles and explains every time. *No, no it means heart right now.*

It’s a joke. It’s a joke.

...Does she know I’m joking?

Does she expect so little of a daughter, blood of her blood, who sucked her marrow from her bones, who gulped her blood for nine months and 22 years after, am I a disappointment every time she says it?

Does she never expect me to know better? To translate right?

আমরা এক পরিবার

(And is it not love in its simplest form, that she expects to—every single time—patiently translate her misunderstood love, and that she never ever tires of it?)

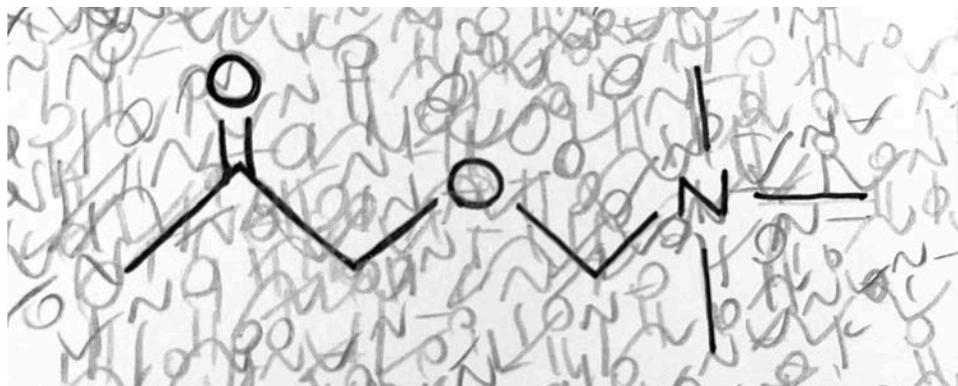


Figure 5: The chemical structure of acetylcholine, used here to calm the heart.

I am a poor cook. Bangla does not say *I love you* as plainly as English. I don’t cook meat, but one day I’ll cook liver for her.

### Confession

The most common neurotransmitters in the brain are GABA and glutamate. Most people don't know of these. I hold my parents and they hold me in return. It's a long standing habit of our neurons: we focus on what we know is wrong (Peeters & Czapinski, 1990).

### Ceiling Fans

I'm upstairs, watching the ceiling fan spin. Maa and Dad are screaming below, each sentence a swipe of the ~~word-sickle~~ scalpel asking

*slice me open, pour my pulpy abdominals onto the floor, because your hands too are bleeding, radial, carotid, pulmonary, and on*

and filling this house to the brim in garbled, rotting, degrading words. I have my own, but they are floating with me, held in locked rooms.

I'm upstairs, floating in brine, watching the ceiling fan spin.

There are no saviors here, but do you think—

I lied to you. There are some neurons that Loewi could not touch. Some neurons, needing to be especially in sync, have electrical synapses: long live the reticular theory. Stapled together at the cleft, one free-flowing path, they let charges speak for themselves. They're often temporary and especially common in embryos (Bear et al., 2016).

do you think we'd need acetylcholine if I spoke proper Bangla?

we didn't need words those first nine months

cowering in the womb

pudgy hands pulling on the umbilical cord

The fan's cords, warm and fleshy, are stretching down to strangle me and slurp up my words.

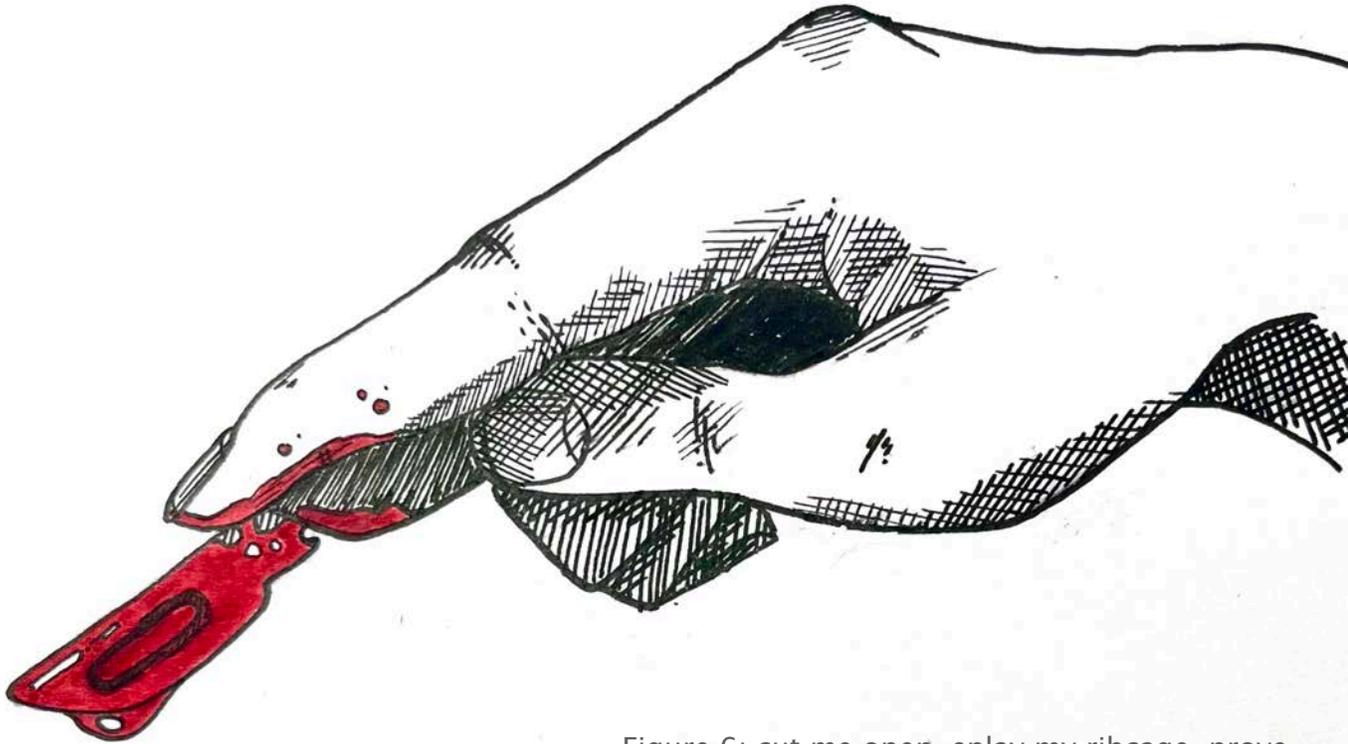


Figure 6: cut me open, splay my ribcage, prove softly that my heart still beats in warm water

I think the **frogs were** mother and daughter.

I think we carry **electricity** and acid in our bodies.

My mother said

*you cannot be soft*

because her heart was soft

My father—surgeon's hands—took the scalpel and cut out her heart

still fluttering and gasping

In that same bath: my frog heart beats.

*lub dub. lub dub.*

### Here We Are, at the Synapse

Loewi is known for bringing revolution and also for dreaming it. The story goes that he woke in the dead of night, jotted down the experiment, and drifted back into inky black slumber. In the morning, he could not read a word of what he wrote, nor recall it. It wasn't until the second dream that he remembered to <sup>translate</sup>redefine what we are (Loewi, 1953).

*(the second dream, the second heart, the second daughter)*

I dreamt of you, Maa (Rasheed, 2022). We were in the ocean (maybe it was the Bay of Bengal, or the Ozarks, or a brine bath) and we didn't speak but you drowned and I screamed in a language neither of us know and we were not saved.

But the second time.

The second time—I will know and I'll have the right words, GABA, glycine, acetylcholine and on, and I'll drop the scalpel to hold your heart in my hands and I'll place the right fruits at your teeth and you'll know what I mean and we'll float, hearts still *beating beating beat*—and we'll have revolution.

But for now—

for now—

I cannot tell my heart to rest.





### Acetylcholine Release:

আমি শুনছি তোমাকে, তুমি শুনছো? তোমার ভাষা আমার মাতৃভাষা নয় আমার কিন্তু হৃৎস্পন্দন কমেছে  
মামনি তুমি আমার কলিজার টুকরা তুমি বুজেছ?  
আমরা কি পানিতে একসাথে আছি?  
স্বাদ পাচ্ছে?

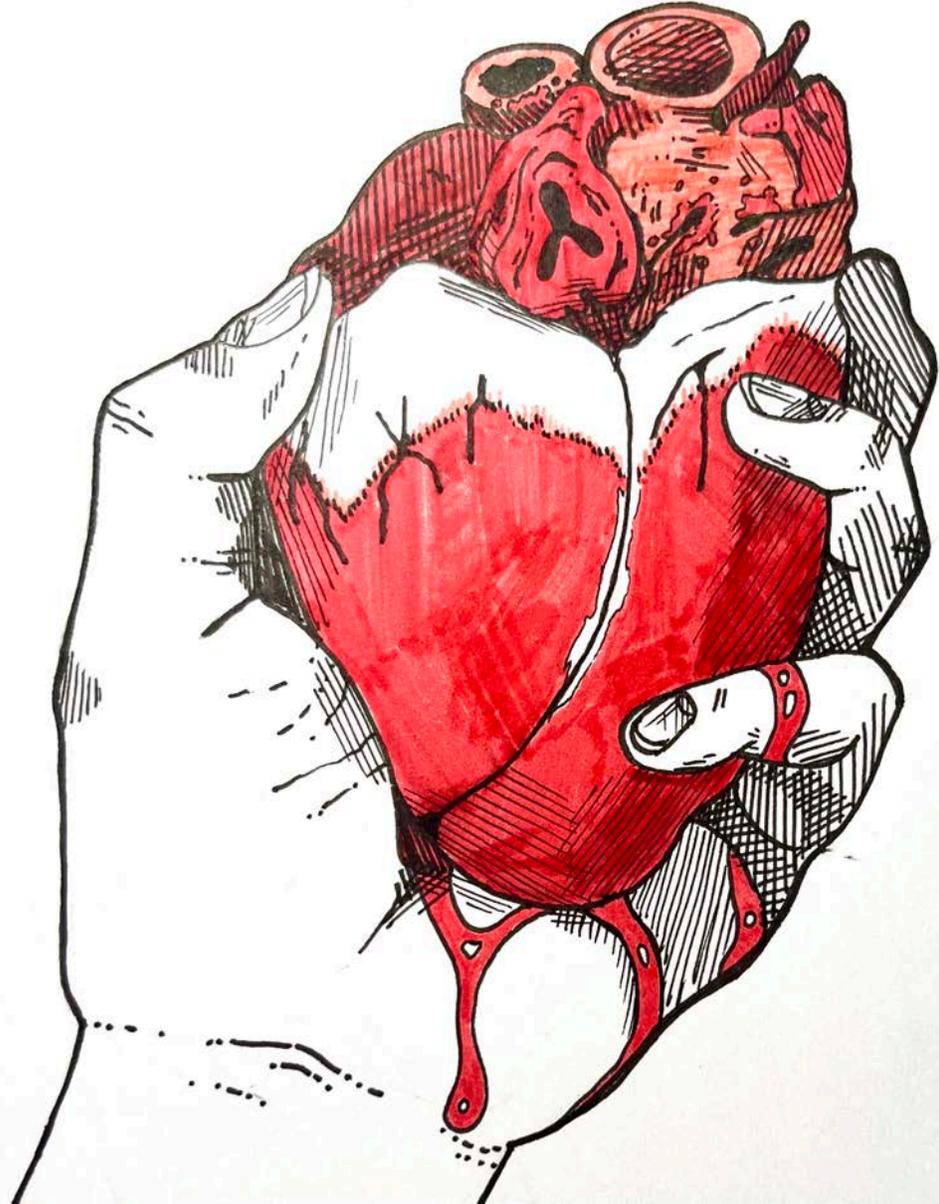


Figure 7:  
আমি তোমাকে ভালোবাসি

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