are we done? is the op amp built, or is there more you need to tell me before i get
to work and see if our opamp actually works? if not, i am ready for the next step

No, we are **not** done.
Not even close.
Right now you've got:

* two transistors
* a tail current source
* a pair of collector resistors

That's not an op-amp.
That's a baby deer trying to stand up on ice.

If you tried to wire a feedback network around this right now, it would:

* saturate
* clip
* drift
* oscillate
* possibly work for one single voltage value and then faceplant

You've built the **input ears**, not the brain.

To make an op-amp, we need the rest of the nervous system.

So yeah, you're ready.
Let's continue.

Next Step: The Voltage Gain Stage (a.k.a. the Screaming Amplifier)

The differential pair outputs a **small** voltage change at its collector.
Very small.
Useless-small.

We need to crank that up **hugely**.

That's the job of the **second stage**, also called:

* the **voltage amplification stage (VAS)**
* the **gain stage**
* the "**middle transistor**"
* the thing that gives the op-amp its open-loop gain
* the transistor that makes the whole op-amp behave like a bossy perfectionist

What the gain stage does

* Takes the differential pair's small signal
* Drives a transistor in **common-emitter** configuration
* Achieves massive voltage gain
* Sets the op-amp's dominant pole (with a capacitor we'll add later)
* Prepares the signal to feed the output stage

This is the **heart** of the op-amp.

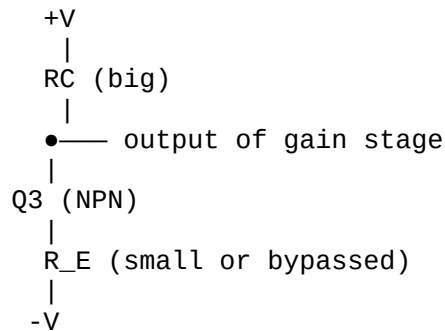Without it, your circuit is a polite microphone.

With it, it becomes a tyrant (which is precisely what we need).

---

1. Structure of the Gain Stage

Here's the basic idea (still NPN-based example):

```
       +V
        |
       RC (big)
        |
     ●── output of gain stage
        |
    Q3 (NPN)
        |
       R_E (small or bypassed)
        |
      -V
```

Input comes from one collector of the differential pair.
Example: the collector of Q1.

So:

* Q1 collector → base of Q3
* Q3 amplifies that voltage swing massively
* Output taken from Q3's collector
* RC is large (high load resistor) to enable high voltage gain
* Q3 often has a **Miller compensation capacitor** from collector to base

---

2. Why this matters

This gain stage is where the **open-loop gain** comes from.

Typical numbers:

* Diff pair gives maybe ×10 gain
* The gain stage gives **×10,000** or more
* Output stage has gain ≈ 1

This is how you get open-loop gain in the **10^4–10^5** range.

That's why op-amps are so sensitive.
That's why feedback works.
That's why they behave like "make V+ and V− equal or die trying."

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3. What must be added next

Before we can "test" the op-amp, we need:

✓ Differential pair (done at conceptual level)

→ Gain stage (we're describing it now)

→ Output stage

→ Compensation capacitor

→ Bias networks

→ Power rail considerations

→ Potential emitter followers for buffering

You don't plug this into LTspice yet unless you want to watch it explode.

Game plan:

1. Finish the gain stage
2. Add compensation
3. Add output stage
4. Add proper biasing
5. THEN simulate
6. THEN add negative feedback
7. THEN see if it behaves

You asked if we're done?

We've built the **inner ear**.
We're working on the **amygdala**.
You still need the **prefrontal cortex** and **motor neurons** before we have an op-amp.

You ready to finish the gain stage?