RELEASE AUDIT | DEVELOPMENTAL DOMAIN | 20 LESSONS

Red-Team Report

Could a student complete every task using only the materials supplied in the lesson package?

RELEASE DECISION

Ready after automated file, reading, deck, document, build, and live-route checks pass.

DISCOVERY INTEGRITY

Each lesson reveals only the evidence needed for its decision. Lesson 20 synthesizes the domain without inventing a single cause.

Audit gates

Gate	Release standard	Result
Durable idea	Every lesson names one 10-year takeaway and one of the four foundations.	**PASS in authored package**
Socratic sequence	Analogy image, observation questions, student rules, biology mapping, decision, defense, and handoff are present.	**PASS in authored package**
Closed loop	All required knowledge, evidence, definitions, visuals, and decision rules are inside the package.	**PASS in authored package**
Case integrity	Stable evidence IDs are used. No task requires invented or student-identifiable data.	**PASS in authored package**
Claim discipline	Each decision states what students may claim and what the evidence cannot prove.	**PASS in authored package**
Reading	Plain-language structured readings are supplied. Publication links are optional.	**PASS in authored package**
Alignment	Guided notes follow the deck roles and end by constructing the day's take-home.	**PASS in authored package**
Visual QA	Every lesson has separate analogy and biomedical illustrations with explicit educational labels.	**PASS in authored package**

Lesson-by-lesson dependency audit

#	Take-home	Analogy	Evidence IDs	Decision	Handoff
1	The lip and palate form in short, ordered windows, so timing narrows where a developmental change began.	A construction calendar with locked phases	DEV01-E1, DEV01-E2, DEV01-E3	Choose the timeline statement and cite the two evidence cards that set its limits.	We answered today's question: Mateo's cleft started in a window between about week 4 and week 12. But if a cleft is a fusion that did not happen, then which exact building blocks of the face were supposed to grow toward each other and fuse? We chase that next time.
2	The face forms when named tissue prominences grow into position and join specific neighbors.	Five puzzle pieces with only certain neighbors	DEV02-E1, DEV02-E2, DEV02-E3	Choose the useful label set and defend it with two evidence cards.	We named the blocks that must fuse. But each prominence is packed with cells that grow and migrate, and we have not asked where those cells come from. So the next question is: where do the cells that build these facial blocks actually originate? We chase that next time.
3	Cranial neural crest cells leave the neural folds as flexible builders that can become several craniofacial tissues.	Students leave one school for specialized apprenticeships	DEV03-E1, DEV03-E2, DEV03-E3	Choose the correction and cite evidence for both mobility and later specialization.	The face-building cells are born at the top of the embryo, near the brain, and break free by delamination. But the prominences they need to fill sit far away around the mouth and jaw. So the next question is: how do these cells travel from the neural folds to the right facial blocks? We chase that next time.
4	Face-building cells must travel in organized streams to the right destination before they can build the right structure.	Transit lines carry different crews to different stations	DEV04-E1, DEV04-E2, DEV04-E3	Choose the defensible prediction and cite the route and cell-number evidence.	The face-building cells ride organized streams into the frontonasal process and the first arch, filling the prominences. But the lip is still open: the blocks have arrived and grown, yet they sit next to one another as separate pieces. So the next question is: how and when do those separate blocks actually close to make a lip? We chase that next time.
5	Upper-lip closure requires growth, contact, and stable fusion at the maxillary-medial nasal boundary.	Two zipper halves must align before they close	DEV05-E1, DEV05-E2, DEV05-E3	Choose the label that fits the animation and cite the boundary evidence.	The upper lip closes at about weeks 4 to 6, forming the lip and the small front triangle of palate. But that triangle is only the front of the roof of the mouth. Behind the incisive foramen, the palate is still wide open. So the next question is: how does the palate begin? We chase that next time.
6	The secondary palate begins as paired shelves whose cell growth must create enough tissue to reach the midline.	Two stage platforms extend toward the center	DEV06-E1, DEV06-E2, DEV06-E3	Choose the primary outcome and cite the evidence linking cell growth to shelf size.	The palate begins as two shelves that grow downward beside the tongue. But those shelves point straight down, with the tongue sitting between them. How do two downward shelves end up as one flat roof above the tongue? We chase that next time.
7	Palatal shelves must rapidly elevate above the tongue, and jaw-tongue geometry can block that movement.	Drawbridges rotate only after a boat clears	DEV07-E1, DEV07-E2, DEV07-E3	Choose the comparison and cite the evidence that separates presence from position.	The shelves remodel and rise above the tongue once the tongue drops and the head widens. But now the two horizontal shelves sit almost

#	Take-home	Analogy	Evidence IDs	Decision	Handoff
					edge to edge at the midline, still separate. What actually lets two separate edges of tissue become one continuous roof? We chase that next time.
8	After elevation, the medial edges must recognize, adhere to, and align with one another before fusion can continue.	A docking spacecraft needs matching ports	DEV08-E1, DEV08-E2, DEV08-E3	Choose the scoring rule and cite the evidence that separates contact from adhesion.	The shelves adhere at their medial edges and form one seam down the midline. But the roof is not truly finished: a wall of epithelial cells, the seam, still runs through it. If that wall stays, the two sides are not really one piece. What happens to that wall of cells? We chase that next time, and the answer turns out to be a real scientific argument.
9	True palatal fusion requires removal of the midline epithelial seam so mesenchyme becomes continuous.	Remove the temporary wall after two rooms connect	DEV09-E1, DEV09-E2, DEV09-E3	Choose the experiment and explain why the endpoint image is not enough.	The seam is removed, by mechanisms scientists are still working out, so the palate becomes one continuous tissue. But the seam cells clear at exactly the right time and place, and the shelves grew the right amount and stuck only where they should. Something must be telling the tissue when and where to grow, stick, and clear. What is that signal, and where does it come from? We chase that next time.
10	Signals such as SHH, BMP, and FGF carry local instructions that coordinate growth, position, and cell fate.	An orchestra follows several section cues	DEV10-E1, DEV10-E2, DEV10-E3	Choose the bounded conclusion and cite source-target and growth evidence.	SHH, BMP, and FGF tell the shelves how much to grow and where, and a missing signal gives a too-small or mis-grown shelf. But growing is not the same as joining: a shelf can grow, elevate, and meet its partner and STILL not fuse. At the last step the two touching shelves must commit to becoming one, and a specific signal flips that switch. What is the master switch for palate fusion? We chase that next time.
11	TGF-beta3 makes the palatal medial edge competent to complete adhesion and seam removal.	A temporary access code enables the final handoff	DEV11-E1, DEV11-E2, DEV11-E3	Choose the step assignment and cite the matched contact evidence.	We found the switch that tells edge cells to fuse. But before any cell can be an edge cell, it first had to BECOME a particular kind of cell. How does a face cell decide whether to be bone, skin, or cartilage in the first place?
12	Wnt-beta-catenin signaling can steer cranial progenitors toward dermal and bone fates while repressing cartilage fate.	A railway switch selects one track and closes another	DEV12-E1, DEV12-E2, DEV12-E3	Choose the strongest response and cite the evidence that rules against simple cell loss.	We now see how cells choose their fate. But fusion happens at surfaces, and surfaces are dangerous: a sticky outer layer could glue the palate to the tongue by accident. So why do not the wrong surfaces stick together?
13	IRF6-dependent periderm acts as a temporary non-stick surface that prevents the wrong oral tissues from adhering.	Protective film keeps stacked labels from sticking early	DEV13-E1, DEV13-E2, DEV13-E3	Choose the causal sequence and cite the surface and movement evidence.	We now know which surfaces must stay apart and which must fuse, and which gene polices that. But clefts come in different forms: some only the lip, some only the palate, some both. Which

#	Take-home	Analogy	Evidence IDs	Decision	Handoff
					exact step fails for a cleft lip versus a cleft palate?
14	A cleft pattern narrows the failed developmental checkpoint, but it rarely identifies one unique cause.	A stopped assembly line reveals a checkpoint, not the culprit	DEV14-E1, DEV14-E2, DEV14-E3	Choose the triage method and explain why the palate list remains broader.	We can now map which step failed and see that Mateo's looks like an isolated fusion failure. But mapping a failure is not fixing it. Each step happens in a narrow calendar window. Is there a moment after which the step can no longer be repaired, so the cleft becomes locked in?
15	A developmental risk matters most when it acts during the short window for the process it can disrupt.	A theater door closes after one scene change	DEV15-E1, DEV15-E2, DEV15-E3	Choose the timing hypothesis and cite the window evidence.	We now know the face has narrow closure windows, and those windows are when it is most fragile. If the embryo is most vulnerable during these weeks, can something from outside the embryo reach in during the window and change whether the face forms correctly?
16	An environmental factor changes risk only when evidence links dose, timing, and mechanism, and risk is not destiny.	Weather changes the chance of a delayed flight	DEV16-E1, DEV16-E2, DEV16-E3	Choose the explanation and cite evidence about probability and case limits.	Yes, the environment can tip the odds during the fusion window. But here is the puzzle: the same exposure can reach two embryos with the same DNA and only one of them clefts. How can identical DNA give different results?
17	The same DNA can produce different outcomes because gene activity and developmental context can differ.	The same music score can sound different under different controls	DEV17-E1, DEV17-E2, DEV17-E3	Choose the testable explanation and cite sequence-versus-regulation evidence.	Epigenetic marks and tiny RNAs let identical DNA give different outcomes, and isolated clefting behaves like an additive, multifactorial trait. But we just reasoned from human DNA, mouse palates, and zebrafish cartilage at once. How do scientists actually watch development happen?
18	Researchers combine lineage labels, live imaging, and model organisms to turn hidden developmental events into visible evidence.	Replay plus colored jerseys reveals the whole play	DEV18-E1, DEV18-E2, DEV18-E3	Choose the method set and cite the evidence for both time and identity.	Model organisms plus live imaging let us watch each step of fusion and pin down which one failed. So a bold question: if we can see exactly which step fails and exactly when, could a scientist step in during the window and prevent a cleft?
19	A rescue experiment supports a mechanism when restoring one step restores the outcome, but it is not yet a human treatment.	Replace one fuse and watch one circuit return	DEV19-E1, DEV19-E2, DEV19-E3	Choose the accurate headline and cite both the rescue and translation-limit evidence.	We can rescue a cleft in a mouse by adding back one signal, but only in the lab and only by editing the embryo's own genes. So we still owe Mateo one thing: the complete, honest developmental story of how his cleft actually happened, assembled from everything we learned.
20	Mateo's cleft is best explained as a developmental pathway outcome with bounded evidence, not as one proven cause.	An evidence board reconstructs a route without inventing a suspect	DEV20-E1, DEV20-E2, DEV20-E3	Choose the summary and cite the phenotype evidence plus the uncertainty evidence.	Mateo's cleft is an isolated, multifactorial failure of fusion in the weeks 4 to 12 window, with the rest of development normal. The developmental team now hands his fusion-failure story to the genetics, anatomical, and clinical teams. Do their stories agree with ours?

Known limits and release receipts

- All patient imagery is explicitly educational illustration. No generated image is presented as microscopy, radiology, or a real clinical photograph.
- Typical care windows are educational examples. The site and documents state that real teams individualize timing and decisions.
- Population data describe groups and do not identify Mateo's individual cause.
- The strongest decision is the first option in the teacher guide, but students must defend it with the named evidence IDs.
- Automated validation receipts are stored with the release and are completed before publication.