Legato: Recap, Reassess, Reload

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***Abstract*—*Legato* is an active learning strategy where a given theme is treated by two small groups of students, in succession. The first group explores the theme and assembles the materials to be used by the second group, for the development of an in-depth treatment of the theme, according to the guidelines rendered by the teacher. An additional specification is to randomize the groups for the final phase. The original description, made in 2015, highlighted the untapped potential of committing the students in a work that was prepared by their peers, but also its potential shortcomings. At the time an experienced comparison with other active learning strategies was not possible. The present communication proposes a new description of the procedures, analyzes the dynamics of *Legato* and common obstacles, and discusses its application in a landscape of other learning strategies. *Legato* provides the option of a rich experience with building knowledge, emulating the legacy processes common to all scientific inquiry.**

***Index Terms*—Active Learning, Biology, Cooperative Learning, Flipped Classroom, *Legato*, Peer Interaction, Small Group Learning, Team-Based Learning.**

I. Introduction

Legato was developed in 2011 for the Developmental Biology course (Human Biology degree, University of Évora, Portugal), as a solution to the dilemma of evaluating the students in this very intricate and challenging discipline. The original idea was to make the students explore, in small groups, two themes representative of the course program, based on the scientific literature, such that a good coverage of essential aspects of the program was made by all. However, the second theme would be derived from another group's work as first theme, and for this part of the work the students were shuffled, thus building new groups at random. This would enable a more focused and matured treatment of each theme, and the final marks would be individualized as a result of each student having a unique history in the course.

Group learning engages students in jobs that involve more or less intensive exchanges, which help them develop cooperative skills that are vital for their future professional lives, to say the least. Depending on the learning model, the students may benefit from other types of stimulation, with further gains to be expected [1]. One of the most interesting features of group learning is the possibility of discovering the added power from working together over problems that would not be amenable to each member on their own [2]. Thus, it can be more than a simple matter of work distribution, and different models will be more or less able to elicit such realizations.

With the *Legato* randomization design, the risks of disrupting harmonious groups and assigning the students to themes they had not chosen were obvious, yet the experience was surprisingly fruitful, for example the students in the initial year expressed resistance prior to being shifted in such manner, but after the final session, they approved it, and with the same degree of surprise. It was obvious, rather, that a powerful dynamic was taking place. *Legato* proceeded for a total of 5 years, with a thorough confirmation of the strengths and weaknesses observed in the first year [3]. Since 2016, it was replaced by a more conventional group learning work, complemented by short exams, in the hope of bringing about a more systematic review of each topic, to foster a commensurate development of formal knowledge. The comparisons prompted by the latter experience made the author realize further qualities specific of *Legato*. The purpose of the present article is to make a fresh analysis of the its dynamics, with a new outline of the procedures, and closing with a comparison to other group learning experiences made by the author in other settings.

II. Outline of *Legato*

A. Overview

With reference to a 20-week semester (15 weeks of classes, 4 weeks of exams, separated by 1 week of preparatory work), the procedure starts at around week 7, because the students need time to develop a general framework of reasoning specific for Developmental Biology. Moreover, the larger part of the group work avoided the main time frames when traditional exams in most courses in our university tend to concentrate: weeks 7 – 10, and weeks 15 – 18. So, the sequence of conventional steps that constitute *Legato* was adjusted as follows:

1. Weeks 7 – 9. Preliminaries:
    1. Practical sessions for introduction to the relevant online databases
    2. Listing of theme suggestions, groups formation
2. Weeks 9 – 11. First phase:
    1. Literature exploration on the chosen theme
    2. Online submission of materials and presentation in class
3. Weeks 12 – 13. Bridge (Teacher only):
    1. Review of submitted materials, feedback and grading
    2. Projecting the final phase by sub-themes
4. Weeks 14 – 19. Final phase:
    1. Cast students by chance, so that groups are randomly

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formed for each sub-theme
2. Development of the assigned sub-theme along the guidelines indicated by the teacher
3. Public presentations session and grading
4. Online publication

Grading is made on the submitted materials and presentation in the first phase, and the presentation only in the final phase. The final mark for each student is the average between the marks obtained from the first and final phases.

B. Preliminaries

Two practical sessions of 2 hours, to illustrate the online exploration of biological databases (HumanCyc, Gene Cards, BioMuta, ExPASy and others) and scientific literature databases (Web of Knowledge, NCBI PMC, HuGE, Sparrho, Yippy, Chilibot, and others), together with techniques for taking advantage of each, with a single hypothetical theme (a gene, a cell type, a disease, etc.) to serve as example. These are best performed with the students' own computers. The second session (scientific literature databases) should be separated by one week from the first (biological databases), and the suggested themes released online during the interval between them, to encourage a greater emphasis on the study of biological databases. Google, YouTube and other popular search media are confronted with the effectiveness of the literature databases.

Each theme comes with a brief synopsis clarifying the scope, and the relevance for the course. For example, “Retina precursor cells – originators of all cell types in the retina, with their specializations and multilayered organization, involving regulatory pathways triggered by Wnt ligands”. Students are invited to suggest themes.

To help out somewhat, especially with themes from latter parts of the program, the language in the synopses is kept in line with the general introduction of the program, given in week 1. Groups are formed by student predilections, a maximum of three students per group, with appointment of each student to their chosen theme done online. In order to avoid overlapping applications, groups must settle on a compromise between them beforehand. Singletons are not permitted.

C. First phase

The groups explore their theme, to produce three types of outputs:

1. An editable essay (limited to 4,000 words, not counting the reference list) with a systematic treatment of the chosen theme, supported by an unlimited number of references from the scientific literature.

2. A selection of maximum 10 PDF copies of the scientific publications judged most relevant by the group.

3. A presentation, to be delivered in 10 minutes, in class. The presentation session takes place on week 11, and allows the whole class to witness the content scope for their year. There is a 5-minute margin, immediately after each presentation, for a brief discussion. The students are informed in advance that a bonus can be awarded to those who make significant contributions to these discussions.

Only the essay and the supporting scientific publications are required, with the option (not encouraged) of including the presentation file, if one exists.

The presentation session takes place immediately after the submission deadline. It is a very important opportunity for the course faculty to detect individual learning weaknesses and provide guidance, for example in speech clarity, facing an audience, self-control, or to call the attention to misunderstandings on how to organize the topics or design a presentation file. Such feedback will pay off generously, with the higher standards achieved by the class in the final session.

D. The Bridge

Each essay and its references are reviewed by the teacher, with amendments and comments made directly on the document. A written global impression on the presented work is included, but only for the submitting group, together with the corresponding grade.

Grading of the first phase has been done on the following criteria: presentation session: 30%; essay: 70% (35% for content richness and scientific accuracy, 35% for organization, clarity and usability). Students must know that overriding any of the imposed limits (duration of the presentation, length or quantity of materials submitted) incurs in penalty. If a discussion bonus is awarded to a student individually, it will be limited to 5% of the grading scale, to be added to the grading calculated for the student's group.

From the reviewing work, the teacher proceeds to deliver guidelines for the final phase, with a varying degree of own input. The limit situations being:

1. Simply select a sub-theme that is well covered (in content and clarity) in the submitted materials, explain the rationale for developing this sub-theme, possibly adding one extra PDF to lend more support. This is the desirable situation; it marks a highly satisfactory performance by the submitting group.

2. The submitted material (probably preceded by a poor presentation) is deemed of little use (for being confuse, misleading, insufficient, out of topic, plagiaristic, etc.), and the sub-theme forgoes most of it, with the teacher being forced to retrieve significant materials and provide a more extensive explanation of what is intended for the final phase. This situation is rare but can happen, mainly for lack of commitment by the group, or, as happened in one case, for a misunderstanding of the selected theme itself.

Most submitted works require a degree of intervention somewhere between these two limits. The feedback provided has a substantial effect on the students, projecting into their participation in groups formed for the final phase, with the resulting adaptation ensuring, to a great degree, the success of the final phase. However, the 50% weight of the first phase is meant to stimulate students to be proficient from the beginning.

The newly formed groups should realize that further database explorations are not required, that they receive the materials needed for their subsequent work, so they can focus

on following the guidelines and preparing for a public presentation of their work.

Examples of the relationship between themes and the sub-theme guidelines that followed, taken from the 5 years of *Legato*, are given in the Appendix.

E. Final Phase

The teacher delivers the prepared materials to each of the newly formed groups: those submitted by the first phase group, with the amendments and comments on the essay, the materials added by the teacher, and the guidelines. It is helpful at this point to disclose the website with links to the presentations of previous years[1], as some groups can acknowledge the quality of their antecedents, previse the presence of their own work on the site, and draw inspiration on how to design their own presentations.

In our case, the final phase overlaps with exams for other courses, hence the choice of a relatively uncluttered schedule (week 19) for the presentation date. On the day before, the teacher will be available for personal elucidation of the remaining questions the different groups may want to pose.

The faculty forming the jury must not have a preview of any of the presentations, to avoid any grading bias, or the temptation to suggest changes.

The final session is publicized in advance of a few days (in university media, social media, posters, etc.). Even if the attendants are only the members of the class (sometimes complemented by a few elder fellows), the fact that it is public is important to raise the commitment levels.

One challenge that has been made, is to try devising an appealing title, as if advertising the group's presentation. For example, “The Secret Life of Thalidomide”, “The Art of Liver in crescendo ma non troppo”, “Latest News from the iPS Eldorado”. This challenge is a way of eliciting a different type of ability in the group, while stimulating the very important habit of taking some distance to look at the work under a different light. The teacher can always provide one.

Each presentation is programmed for 20 minutes, with 10 minutes for discussion. All members of each group must take part in the spoken rendition. The discussions time starts with questions from peers, then from the public, finally by the jury, to highlight the performance, make remarks, and further comments as they see fit. The performance of each group is judged on the ability to fulfill the guidelines, the quality of the presentation and the response to feedback, then graded in consensus among the jury members. Bonuses apply as in the first phase.

Each group must be prepared to take notes of all interventions, in order to incorporate them in the final version of the presentation file, to be submitted to the teacher, who will post it on the presentations website by week 20. This final version must also contain a list of references.

III. DYNAMICS OF *LEGATO*

Legato provokes highly productive behaviors in most students. The work in small groups, and sense of commitment to a learning project, are very important for unfolding unsuspected potential [2], but with *Legato* are infused with the intriguing, temporally separated, interplay between groups: each theme is treated in two phases by two different groups, the first exploring a field of their choice and taking advantage of personal affinities, and the second, less likely to have such built-in affinities, developing a final product, steered by the proposed teacher's guidelines, which on their part have relied on the initial work by the first group. There is a continuous thread towards a common achievement, one that links different players in different phases, different settings, different outcomes.

In fact, it is obvious how *Legato* emulates scientific legacy, a heritage in shared knowledge where each one’s achievements are built on previous efforts, but at the same time complementing these, shedding light or focusing what was only hinted at previously. Such emulation can be highly formative in students that are to become future scientists.

One might think that *Legato* begins specifically only with the shuffled groups and their sub-themes, because it is then that they receive a legacy from a different authorship, molded by the guidelines provided by the teacher; but, in reality, the advance notion that the group's work in the first phase is just a stepping stone toward the final outcome, imprints on that early group a sense of responsibility, also a prospective link to the still unformed random group that will carry on the development of the theme. They know that the materials they submit will be passed on to such group, with the comments and amendments made by the teacher, and this adds an ounce of care on their preparation. Hence, during the presentation (first phase), everybody is paying attention to all themes, because the draw for the final phase is still unknown.

The latter aspect singles out another interesting outcome of the process. For most students, the acquired knowledge from both presentation sessions, with the personal emphasis on each one's unique experience, turns into a community of knowledge that is unique to the class. The final public session is a celebration on Developmental Biology, a showcase of the relevance of this scientific discipline for the advancement of Human Biology knowledge, and, most of all, of the proficiency attained by the class.

A feedback-rich activity is the hallmark of many successful learning experiences [1]. Feedback from the teacher, in *Legato*, starts with the first phase presentation session at the latest, continues with the written assessment on the submitted materials, differentially conveyed to the authorship (intercalating amendments, comments and a global impression, as well as the grade given) and to the incoming, randomly assigned, group (only the amendments and corrections), then proceeds with the guidelines provided for the sub-theme, the proposal of a final title, and the final

[1] Currently all presentations can be accessed through the URI https://bh-bd-weebly.com, or, if just for the ones that carried out Legato in the first five years, at http://bh2013bd2015.yolasite.com (the contacts page links to previous years).

session assessment. Peer feedback exists as well, albeit informally and in a more variable manner: comments and questions during the presentation sessions and internal (within each group) feedback exist to some extent, but the most interesting part, specific to *Legato*, is the communication between the groups working on the same theme in different phases, freely exchanging ideas and reading materials. Last but not least, the teacher also receives feedback on the chosen themes, through the contents and treatments that the groups make; this is a major benefit granted by the freedom bestowed upon the groups. In particular, the author always felt obliged to formulate each set of guidelines for the final phase such that it would emphasize the good work in the first phase, knowing that this level of recognition would not be missed by the corresponding groups. *Legato* draws each group and the teacher to create knowledge together, such as in Collaborative Learning [4], albeit in separate phases.

IV. Obstacles

Adapting *Legato* to other learning contexts requires that the four essential phases are followed through, provided they fit into the time constraints of a course. This section analyzes four aspects that might be raised as possible obstacles to this implementation, outlining what can be expected, on the author's experience, and advancing possible actions to be taken.

A. Random groups

Randomness in the final phase is possibly the smallest obstacle. The experience with *Legato* has shown that the final phase proceeds smoothly and with highly satisfactory results, generally exceeding the performances in the first phase. A rationale for this can be made from comparing both phases, underscoring the importance of factors other than the familiarity in the group or the initial interest in a theme of own choice (Table I)

TABLE I: Contrasting conditions of the first and final phases of *Legato*, highlighting factors that favor group cohesion and effectiveness.

Condition	First phase	Final phase
Group formation	Personal preference (mostly)	Random
Theme	Own choice	Random
Previous knowledge of the theme	Superficial	Introduced by peers in the first presentation round
Objectives	A broad unconditioned approach, presentation techniques training, leaving a legacy	A focused guided approach, to produce a scientific (review) communication
Guidance	Minimal (synopsis, online tools)	Guidelines devised by teacher, supported by previously assembled materials
Allegiance to peers	Projected continuation by a random, unknown group	Legacy from a group who is known
Presentation session	Private, no previous feedback	Public, with personalized feedback on first phase session
Grading of the presentation	30%	100%
Presentation document	Delivery not encouraged	Delivered for public posting

Of 33 random groups formed over 5 years, only 2 had major problems in the final phase, both for the absence of one of the two group elements in the presentation session (one for a health situation, the other for lack of confidence of the deserter), not lack of quality of the work presented by the remaining group element. Aside from that, there were som unremarkable deliveries (merely satisfactory), suggesting poor group functioning. Importantly, such cases were quite few.

B. Faulty legacies

The first phase was much more variable in the outcomes produced. The most obvious problem was with 'leftover' groups, formed by odd students that were, for some reason, outcast by their fellows. Lack of commitment, of preparation, of complicity, and sometimes even of understanding of the theme they chose, are more likely to happen in such groups. In every class at least one such group is expected to occur, and if possible, the teacher ought to spot them in advance and try to diagnose problems and encourage for a good outcome. There is also the tendency to write the essay with the teacher in mind instead of seeing their work as a legacy that must be properly curated in order to be usable by their peers in the final phase. This demand is understood by the students but remains strange to some of them, and the teacher should strive for convincing the whole class to adhere.

Faulty legacies demand a greater investment by the teacher to ensure good conditions to all groups in the final phase: besides making written corrections and conceiving a sub-theme with its guidelines for the final phase, the teacher may have to fill in content by explaining the gaps in the essay and providing additional literature relevant for the satisfaction of the sub-theme. There are prophylactic ways to stimulate better performances, for example the students must know that the amount of teacher's investment will aggravate the grades in the first phase, or have the notion that, under this learning model, a good work in the first phase firmly directs the final phase, leaving less room for guessing on what the teacher will come up with for the sub-theme.

C. Managing content

The teacher has the initiative of proposing themes, such that these offer the students the possibility of choosing among different course topics. However, the actual choices are unpredictable, with the potential of concentrating the content coverage on particular parts of the course program and leaving others completely uncovered. The teacher, while designing the sub-themes in the final phase, might have an opportunity to compensate this later, but preventive measures should be favored.

In the case of the Developmental Biology course, concepts delivered in different parts of the program are so intertwined that the set of themes chosen by the groups in the first phase is never too far from achieving a reasonable program

coverage. However, especially in courses where different parts of the program can be mutually independent, the content coverage may become a concern. Restrictions on the choice of themes can be applied, say, for a set of major parts of the program, at least one theme from each part must be chosen (the teacher must indicate which part of the program a theme relates to). As the students must among groups to avoid conflicts over theme choices, such restrictions need not interfere with the groups sense of commitment to the themes they choose – provided that a sufficient number and variety of themes is available, so that the margin of choice is comfortable.

D. Large and small classes

In the past 8 years, 4 to 8 groups were formed in each Developmental Biology class, formed by 2 students (ideally), 3 maximum. The experience suggests that the number of groups should be preferably between 5 and 7. A smaller number limits the scope of content that is covered (but the teacher, as noted above, can do something about it in the way the sub-themes are laid out), and a higher number is definitely challenging to the practical and conceptual demands of *Legato*. It is extremely important that the presentations, in both phases, take place in single sessions, for the concurring goal of building a community of knowledge. However, this can be subjugated by the mounting weariness of succeeding presentations in one whole-day session, and 8 groups can already be too many.

The bridge phase can amount to overwhelming work on the teacher when there are too many groups. But having two or more teachers collaborating in the grading and feedback work — assuming that they operate on very homogeneous criteria — will allow more groups; in that case, two consecutive sessions in the final phase would be tolerable, provided that all students attend both. Such arrangement has not been tried. Even then, *Legato* seems to be unfeasible in a class beyond the limit of 40 students.

V. MISSING *LEGATO*

A. The recent experience, or discussing content coverage

In recent years, concerned with the fact that many students tended to neglect the class contents, judging that this was only relevant for their evaluation indirectly, the author decided to intercalate short exams (5 over the semester) with a 60% weight on the final mark, and keep the formation of groups on their themes of choice with a single presentation at the end of the semester (week 19), for the remainder 40%. In week 15, during the last class, the groups make a short 5-minute progress report orally, allowing the opportunity for correcting some misconceptions and providing feedback on how to make the best approach, and also advise on difficulties in presenting.

It was hoped, by keeping the latter group assignments, this would enact an abridged version of *Legato*, but it was instantly realized that, by missing the legacy element, the whole of it was simply gone. After 3 years with this new experience, it is possible to make a matured comparison. On one hand, one has a better guarantee of covering the course content, but on the other hand the sacrifice of the whole learning experience that *Legato* brings is badly — badly! — missed. While the final presentations are in general of good level, some are relatively poor (as was NOT seen in the *Legato* days) and there is much less involvement with the overall community of knowledge – obviously, each group has their own thing, and it is the teacher they present to.

Currently we are considering a return to the original format. Leaving aside the discussion of what parts of the content are retained by each student after the course (even with the best possible coverage by evaluation), other aspects of learning are weighing heavily on the decision to make: the students' experience of developing a pair of themes in the lines of *Legato*, together with the building of a community of knowledge through such collective work, is likely to lay down a deep assimilation of knowledge, and perhaps more importantly a correct attitude towards scientific knowledge in general. This is clearly felt in the evolving attitude of at least part of the less performing students, over the semester. Thus, it is not surprising that the bottom line of collected content from the Developmental Biology course might be better, let alone equal, under *Legato*.

B. Comparing with Flipped Classroom

The Flipped Classroom protocol is designed to enhance active learning by encouraging students to create and present learning content for their peers [5], [6]. It is a highly supervised activity, given the fact that the teacher supplies all background through a recorded lecture (or analogous procedure), and each group is given a very precise assignment that, together with the other groups, completes the teaching initiated by the teacher.

This option was tried in a module of another course [7], where the students had the tendency to postpone their application to learning from original research articles to the days close to examination. Their attitude in the intervening lessons was passive, and the grades were in many cases disastrous. With the Flipped Classroom tasks, that filled the two weeks devoted to the articles, the accumulated marks obtained by the groups (30% of the module) were complemented by regular exams, where questions on the articles were also included. This application of the Flipped Classroom procedure was very successful in correcting the problem, and the grades in the regular exams improved dramatically.

Legato has similarities with Flipped Classroom: the latter advances a legacy (from the teacher), and groups are complementary to each other, building the shared knowledge within the class that is later probed in the exam. However, the scope of each activity is rather narrow, with little freedom for the groups to go beyond assigned tasks, and most importantly the legacy is from the teacher, not from their peers.

C. Comparing with Team-Based Learning

Team-Based Learning, or Team Learning, is a highly structured activity designed to change loose groups of individuals into highly performing problem-solving teams [1], [2], [8]. This learning strategy goes much beyond content learning, for the deep learning that builds from such change has manifold implications, highly relevant in future real life, on the abilities of each team member to interact, trust the unfathomable powers of their collective, and feel the reward of overcoming challenges that would be practically impossible to tackle individually [2].

In this conference I am, together with my colleague Diogo C. Figueiredo, presenting our experience with a partial application of Team-Based Learning in a course of Evolutionary Biology, for Biology undergraduates. It was used to promote commitment in class and raise motivation to study this course, and it was very successful in helping the students 'come to life' in class, with a genuine interest in the themes that were proposed to them.

The aspects of *Legato* that resemble Team-Based Learning the most, are the change process, and the importance of the many types of feedback that take place. In *Legato* the teacher's role in providing feedback is felt more personally, since each group in the first phase is prompted in specific terms, first in the presentation session, and later, more incisively, in the corrections and global impression on the submitted materials. The corrections, and the sub-theme choice and its guidelines in their context, are also inspirational for each group of the final phase. Such feedback has synergism with the co-responsibility that smoothly binds the groups of both phases, linked by the shared theme/sub-theme and materials. The quality-pregnant performances in the final presentations attest the change of each random group into an effective team.

However, Team-Based Learning has many differences, related to its specifics: it takes place mostly in class, the groups are recommended to be made of 5 to 7 members, and all groups work on the same assignments simultaneously, with their outcomes instigated more by competition between groups than by complementarity [1]. What is more, the degree of autonomy felt under *Legato* is much greater than in Team-Based Learning; in the latter, there is some degree of autonomy especially in the team Application Phase (and, optionally, in the Appeals), where the decisions proposed by each team must be sustained on argumentation that is, in essence, open-ended [1]. In *Legato*, autonomy is highly important during the first phase, by the freedom of approach that is bestowed upon each group, together with the sense of responsibility toward the group of peers the theme will be passed on to. In fact, the groups feel that they are exploring knowledge on their own, reinforcing their sense of commitment, and at the same time knowing they must help make the materials usable by their peers in the final phase. And, in *Legato*, the class each year develops a unique blend of themes, building a notion of uniqueness that can be quite important to reckon with. Of course, autonomy belies the danger of misdirected work, especially in the 'leftover' groups mentioned above (section Faulty legacies).

It is noted that Team-Based Learning is highly adaptable to very large classes, something that *Legato* seems unsuited to.

VI. Conclusion

A. Uniqueness of Legato

It was the way students performed under this model that evoked the prospect that *Legato* constitutes an interesting option for active learning in small groups. The surprising performance with the random assignments in the final phase, and the consistent maturation found in the final presentations, together with the missed qualities in the learning process when substituting a more conventional group assignment scheme for *Legato*, indicate that *Legato* can be a valuable strategy for the development of knowledge, not only in Developmental Biology, but in many other areas of Higher Education. In the original version, *Legato* combines uniquely:

- A range of themes to choose from (and the possibility of suggesting them);
- Experience with specialized search tools and literature;
- Peer collaboration;
- Freedom of exploration;
- Peer legacy and co-responsibility;
- Community of knowledge by the class;
- Singularity of each class;
- Opportunities to correct the paths taken;
- Maturity of theme treatments;
- Amelioration of presentation skills;
- Experience with randomly assigned groups;
- Public exposure.

B. Pondering the downsides

Classes that are either too small (under 8 students) or too large (over 24 students) do not conform to *Legato* well. Certain adaptations can, as discussed, extend to 40 students at maximum.

Aside from the prohibitive numbers, the main concerns are:

- Being watchful over the performances in the first phase, such that the legacy component is not missed; and
- Assess the possible problem of not covering the program adequately.

The latter seems to be a lesser concern, unless the representation of different parts of the program is too unbalanced, but preventives (rather than a remedies) can be set, as discussed.

Appendix

Examples of first-phase themes and corresponding guidelines (shortened) for the sub-themes in the Developmental Biology course.

Theme (program part)	Guidelines
Keratinocytes (2 – Differentiation)	Develop a timeline for the differentiation path, from basal cells to cornification, signaling the main phases and relevant markers for each

p53 (1 – Growth)	Establish a relationship between different types of cancer and the type of p53 inhibition identified in each
Vestigial organs (3 – Morphogenesis)	Define the functionality of the vomeronasal organ, highlighting its development, physiology, the clues from other mammalians, and the pheromone hypothesis
Liver regeneration (3 – Morphogenesis)	Outline evidences on how a regenerating liver 'knows' when to stop growing, with emphasis on the signaling hubs MST/Hippo and mTOR
Catch-up growth (1 – Growth)	Explore the causes for an immediate (type A) and a protracted (type B) growth response: genetics, environment, or the pathology that caused the previous delay and its treatment
Tooth ontogenesis (3 – Morphogenesis)	Explain the 'sculpting' processes taking place in the primary, secondary and tertiary dental lamina, to give rise to the different types of teeth
Lymphoid lineage (2 – Differentiation)	Explore the role of Notch signaling in the developmental splitting into lymphoid subtypes, its correspondence with leukemia types, interactions with other signaling pathways, and as clinical target
PDGF (1 – Growth)	Outline the distinct functions of the diverse PDGF ligands and their receptors, and draw conclusions on the importance of such specializations
miR-10b (2 – Differentiation)	Collect the information necessary to update the connections between Twist-activated genes (miR-10b included) and metastasis induction, and explore the literature on antagomiRs for cancer treatment
Lung development (3 – Morphogenesis)	Elaborate on the mechanisms and common molecular actors of branching morphogenesis in epithelial structures

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