Drawing to Learn

Science, Technology, Engineering & Maths

Pauline Ridley and Angela Rogers

Visual Learning in Higher Education

Drawing to Learn
Each of the booklets in this series is addressed to a broad cluster of disciplines and offers a brief introduction to the ways in which drawing and other visual methods may be used to support undergraduate and postgraduate learning and research. We hope the ideas and examples will encourage lecturers and supervisors to explore the possibilities in their own teaching. More resources, including downloadable materials and detailed guidance on the activities and approaches mentioned here, are available online at
www.brighton.ac.uk/visuallearning/drawing

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Visual Learning in Higher Education "Drawing to Learn" is one of a number of publications and online resources developed through the LearnHigher Centre of Excellence in Teaching & Learning* to support the development of visual/spatial/tactile knowledge and skills in undergraduate and postgraduate education. These may include: observation and recording of visual data (for instance during field visits or in laboratories or clinical settings); evaluation and analysis of visual evidence; effective use and understanding of visual methods of communication and research. Further information and resources can be found at
www.brighton.ac.uk/visuallearning

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For further information and resources for university staff and students on many other areas of learning development see **www.learnhigher.ac.uk**

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Front cover: Pauline Ridley
Back cover: Darwin's 'Tree of Life' sketch. Reproduced by kind permission of Syndics of the University of Cambridge Library

Series foreword: How can drawing support university study?

Drawing and other visual practices have an important role to play in every discipline – not just those with which these activities are usually associated.

Drawing helps to sharpen **observation** skills, a vital element in many subjects, and enables rapid and accurate recording of key data in almost any situation.

Equally, **conceptual drawing** and diagramming requires students to make explicit and tangible their understanding of abstract or complex ideas and processes. By doing so, it provides a basis for these to be discussed, explored and challenged – a powerful way to develop critical thinking and reinforce memory and understanding. Visual approaches can also be valuable in cross-cultural student groups where linguistic uncertainty could cause misunderstandings.

The ability of drawings and other visual images to provide a trigger for discussion and dialogue means they can be used to develop **communication** skills, to encourage students to reflect on their own experience, and to explore professional and personal goals and plan for development.

The potential of images to encode large amounts of information economically also serves an integrating function. Images are fundamentally analogic, triggering a web of associations with familiar domains.

Judy Martin

Analogic thinking and visualisation are recognised elements of higher order thinking and contribute to effective **problem solving skills** (Kaufmann, 1990; Marshall, 1995). For all these reasons, image-based techniques are also valuable **research** tools.

Given these potential benefits, it may seem surprising that, in most subjects, drawing and other visual skills are somewhat underused and rarely taught directly at undergraduate or postgraduate level. A variety of social and historical factors lie behind this omission: a general undervaluing of sensory and technical knowledge which in Europe may be traced back to the rise of the academies between the sixteenth and eighteenth centuries; philosophical traditions which value the life of the mind over that of the body; and longstanding differences of status and income between 'manual' and 'intellectual' forms of work.

More immediately, school experiences often convey the impression that drawing, copying and colouring, while valuable as learning tools in the early years, should be left behind once reading and writing are established. At the same time, widespread (mis)conceptions about self-expression and creativity have sometimes deterred teachers from helping children to acquire basic drawing skills, an omission which then leads to lack of confidence and fluency. Consequently, many people arrive at university assuming i) that drawing is childish and/or irrelevant to academic work, ii) that it is something only artists do, and iii) that they themselves are 'no good' at it.

We need to challenge these beliefs. We expect all students to be literate and numerate even though few of them will become professional writers or mathematicians. Equally, drawing and other visual-spatial skills can be learned by anyone, at any age, to a sufficient level for most practical and conceptual purposes.

However, the barriers described above may also make lecturers hesitate to introduce drawing into their own teaching. We hope this booklet and associated online resources will help overcome any such reluctance. The approaches described here and on the website have been developed and used with academics in many disciplines at different universities. They do not require specialist skills or materials and most can be incorporated into standard teaching sessions. We hope you will try them out and contribute your own ideas and examples via **www.brighton.ac.uk/visuallearning/drawing**

Drawing in Science, Technology, Engineering and Mathematics Higher Education

Observation and recording

In my experience, the only way to be sure I'm looking carefully enough at something – particularly something with lots of detail – is to draw it. The vital importance of this is that there may be something new and unexpected there; unless I draw I won't look carefully enough to see the unexpected.
Adelaide Carpenter, genetic scientist (quoted in Phipps, 2006).

Whether looking down a microscope, or studying geological features on a field trip, drawing forces us to pay closer attention to what we see. In the past it was the only practical means of recording the appearance of humans and animals, objects, landscape features and other natural forms.

Most of these functions have now been taken over by photography, video and digital microscopes, but students often 'consume' such images uncritically. Drawing (directly or from photographic images) pushes all of us to look for longer and to ask *'What is this I am looking at? Why does it look like this? How else might it look? How does it relate and compare to what else I know?'*

Even students with good science qualifications may now arrive at university with little or no training in accurately drawing and annotating observed phenomena. Wherever possible show students your own field or lab notebooks and provide clear guidelines on what constitutes a 'good' drawing for specific purposes.

Geology field sketch book page with photograph for students to compare

Checklists can help students understand and internalise the appropriate criteria for different tasks. Encourage them to examine each other's drawings – in class or in the field – to explore the different ways that information is recorded, discuss mark-making strategies or standard conventions for recording features, and consider what has been included or omitted. In large classes, digital visualisers can project a live image of a drawing being created by the lecturer in real time, to demonstrate how and why particular information is recorded, and how to annotate it.

Students will also benefit from more informal observational drawing. Encourage them to carry around a small notebook at all times to make rapid sketches of relevant subjects, both directly and from memory. The more regularly they do this, the more acute their perception will become.

However, students more used to drawing in an art context may aim for a pleasing image rather than an accurate and relevant record, while those lacking confidence in their drawing may rely on schematic representations of what they think is there. So show them varied examples of observational sketches, and discuss these in terms of what has been noticed rather than aesthetic qualities.

Give students plenty of opportunities to develop their confidence. Re-drawing after an initial sketch can push them to see in more depth and elaborate their original observations. Copying and colouring are also effective ways to learn to look and to reinforce memory. Copying removes anxiety about rendering a likeness and allows students to focus on structure and detail, and many people attest to the study value of the detailed specialist colouring books published on topics such as microbiology.

For study purposes, drawing skill is mainly a matter of practice and reasonable eye-hand coordination, and is much less important than the ability to look really carefully. There are several widely used exercises, which could be used in introductory sessions and practised independently.

One such is '**blind contour drawing**', where the surface on which you are drawing is masked in some way, to focus attention on the subject and the process of looking rather than the drawing as an image. The simplest way to achieve this is to push a pencil through a spare sheet of A4 paper and then hold the pencil below this, so that the paper conceals both hand and the drawing surface below. Now focus on the outline of the object being observed and while following it round with your eye, trace the same contour with your pencil without looking down or lifting the pencil from the paper.

Another common approach is to use a **viewfinder** (made by cutting out a rectangular 'window' in a piece of card) to frame what you are looking at and help concentrate on a small section at a time. In the same way, a **squared grid** overlaid on a source drawing or photograph will enable you to copy this more accurately and notice the fine details in each section. Other looking & drawing exercises can offer opportunities to sharpen perception of variations in **tone**, **colour** or **texture**, while **drawing from touch** reminds us how much knowledge we gain through other senses. Place objects inside boxes or bags and ask students to feel these with one hand and draw with the other. They have to discern the object through touch and then visually express this on paper, moving from one modality to another.

Lecturers report that many engineering students have difficulties in visualising three dimensional structures or spaces from diagrams, especially if they are just used to making and reading technical drawings. It can be helpful for them to try drawing more freely and fluidly, using the activities mentioned above as a starting point, and also to find different ways of moving back and forth between two- and three-dimensional representations. In one drawing workshop, the group was divided in two, and given a different collection of objects to draw, in separate spaces. The groups then exchanged drawings and built large models in cardboard, based only on the information in the drawings they had received. They then came back together to explore what they had learned from the process.

http://urbangov.wordpress.com

Conceptual drawing, mapping and visualisation

Scientists have always used drawing as a way of seeing the natural world, explaining it, understanding it. Sketching out an idea on paper is an instinctive way to test your idea, identify its flaws or discover new possibilities that your imagination alone cannot see.
(Armand Leroi, Professor of Evolutionary Developmental Biology, Imperial College London, The Big Draw, 2008).

In any subject, the habit of giving tangible form to abstract ideas is beneficial. This is particularly important in STEM subjects, which rely heavily on diagrams, maps and other kinds of symbolic representations to communicate and test ideas. In many disciplines these are a field of study in themselves, and space does not allow discussion of such specialist uses here. However, there are many other visual approaches that can be be productive in any branch of science.

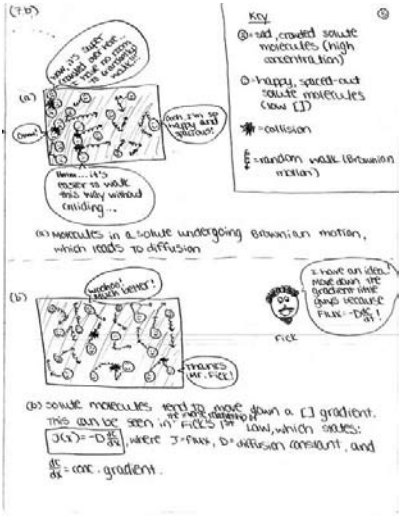
Studies (Kozma & Russell 1997, Tasker & Dalton, 2006) have shown that even well-qualified science undergraduates may take a simplistic view of diagrammatic representations, often interpreting them too literally. This can lead them to hold on to fundamental misconceptions that inform their day to day thinking, even though they may reproduce theoretical knowledge accurately in their written examinations. Drawing and other image-based work can bring such tacit theories and assumptions to the surface, while also helping students to develop a better understanding of the relationship between symbolic representations and the phenomena described.

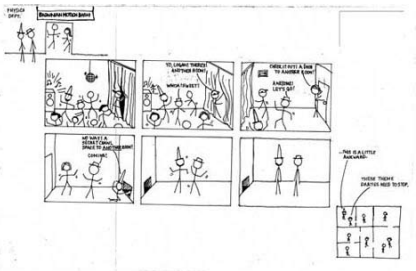
Get students to create quick freehand drawings or diagrams in class to represent key concepts or processes. This helps them to clarify their own understanding of ideas. The group can then compare and discuss the different versions, enabling them to explore ambiguities as well as correct any misunderstandings.

The Picturing to Learn project, part of Harvard University's Envisioning Science Program, has taken this one step further by building the process into undergraduate assignments. Science majors create freehand drawings to explain a given topic (such as the quantum behaviour of particles) to a non-expert; these are assessed on the extent to which they demonstrate and clarify key scientific concepts. The project website is at **http://www.picturingtolearn.org**

Mind maps, especially when these include schematic images to represent individual elements, can help individuals or groups to build up a 'bigger picture' of complex systems or subjects. Recording group discussion on whiteboards or flip charts makes the thinking process visible immediately. Unlike text which is read in a linear sequence, mind maps and diagrams allow a great deal of information to be apprehended simultaneously. Mind-maps are also useful as aide -memoires and tools for revision.

Timelines and storyboards Drawing gives us a way to investigate and play with sequences of events. Standard formats such as annotated timelines and storyboards (short comic strips) can help students to visualise and communicate ideas about what has happened in the past or to project into the future. For instance, such formats could be used to show a sequence of chemical reactions, geological periods, the impact of environmental changes or any other time-based process. Computing and any other courses which involve user needs analysis might use story boards for this purpose. A4 paper and post-its are sufficient in most cases, but if the teaching space allows, the whole group can create a giant timeline or story board on the floor or wall, using large sheets of lining paper. The physicality of such activities often reinforces the impact on learning.





Collage

For most kinds of conceptual mapping and visualisation, basic tools such as pens, pencils and paper are enough. However, there are times when collage (constructing a picture by sticking images or other materials to a surface) can be even more effective.

Collage seems to work best when we move from the intuitive to the conceptual so it is an appropriate medium for exploring identity, ethics and professional dilemmas. You may want to provide images that relate directly to the subject matter of the session but this is not always necessary, as students will bring their own associations to quite random collections of material. Either way, it is helpful to collect images in advance from a variety of magazines or newspapers to give plenty of choice.

Ask each student to make an initial selection of images that relate to their beliefs or experiences or understanding of the given topic, or even just attract their attention for reasons that they cannot rationalise. They then combine and arrange these – according to whatever system of connections makes most sense to them – and stick them down on a large sheet of paper. (If space is very limited, small collages on postcards can also work well.) In small groups, students then discuss their collages and may add signs and text in the light of this..

A good way to extend collage activity is to make A4 or A3 colour copies to look back on at a later date or to cut up and integrate into new collages. This iterative approach helps students review their thinking over time and reflect on their own learning.

Angela Rogers

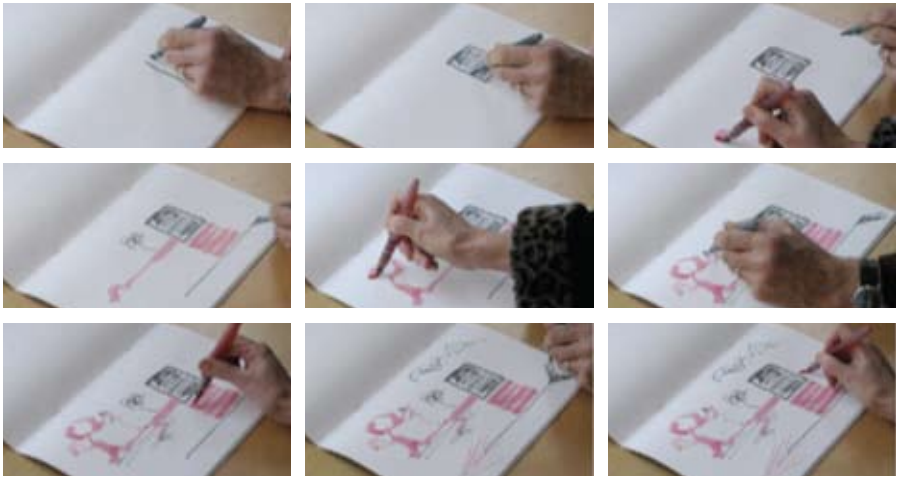
Communication, reflection and dialogue

More important than thought is what leads us to thought, impressions that force us to look, encounters which force us to interpret, expressions that force us to think (Deleuze, 1964).

For most of the activities described in this booklet, the greatest benefits come from using the drawings that people have produced as a trigger for subsequent group discussion and reflection.

Drawing can also be used to support students' ability to reflect on their own learning and professional development, and to build their awareness and skills in relation to interpersonal communication. The relevance of the latter may seem stronger in some subjects than others, but even in the 'hard' sciences, the ability to communicate effectively with colleagues and the general public is increasingly seen as an important skill. In addition, many STEM subjects expect students to be able to undertake interviews at some point in their course – for instance, liaising with clients or user groups in computing or engineering, or as part of small scale qualitative research projects in eg geography and environmental sciences.

Paired drawing, in which each participant in turn adds to the drawing, building on each other's contributions, is a great way for students to explore the dynamics of one-to-one communication. The lessons learned will be relevant to their professional interactions with colleagues and to any other kind of one-to-one work. In these 'drawing encounters':
…the process of improvising the rules of engagement, and negotiating the shared territory, is made visible, and the paper becomes an arena for mutual reflection and collaborative inquiry. (Rogers, 2010).



Angela Rogers

Collaborative drawings drawings are a particularly good way for a group to share hopes and fears at the beginning of a course or reflections on their learning. For instance, to explore beliefs about professional identities, you might ask students to discuss and draw – in and around a life-size outline figure – the attributes of the professional they aspire to become. This can help prompt discussion of whether these expectations are realistic.

As a follow-up activity, they might produce maps or storyboards to represent the learning journey between their current state and where they want to arrive. Drawing is an intuitive strategy open to all, and the sensations and emotions that it triggers can be an effective catalyst for deep and critical thinking. One workshop participant wrote afterwards:

…it showed [us] that drawing depicts concepts in a very emotionally raw way, and that people are accessing their thoughts and feelings via quite a different route than when verbalizing…

However, with any teaching activity that may elicit deep seated feelings, it is important to be clear in advance about why students are doing this and to agree guidelines on confidentiality. Because there is no fixed language of visual expression, drawing offers a valuable element of ambiguity in interpretation, allows feelings to be expressed but not necessarily to be apparent to other participants. Students can choose how much or little to elucidate.

It is useful to consider with students how any drawing activities might be adapted for working with people outside their own discipline. The absence of a shared specialist vocabulary can often hinder communication between professionals and members of the public, but making something visual can provide a bridge. For instance, in some branches of geography and environmental studies, participatory mapping or diagramming are recognised methods of gathering information (Herlihy, Pain). Practising such activities for themselves develops students' understanding and confidence about using such methods in their future work.

http://urbangov.wordpress.com

Research

It has become increasingly clear since the latter half of the 20th century that knowledge or understanding is not always reducible to language. (Eisner, 2008).

In the same ways that drawing can support learning and teaching, it is a valuable addition to every stage of research. Qualitative research in most disciplines still relies mainly on written or spoken language, with questionnaires, interviews and focus groups dominating most students' assumptions about research methods. However, as we have seen, visual methods are effective in helping respondents to access areas and levels of experience that may not easily surface in verbal form. They could and should take their place in the researcher's toolkit.

As with any other research process involving human subjects, normal rules of ethical procedure and informed consent apply. We must also stress that the aim here is not to produce images to be interpreted by the researcher but to use them to prompt and support meaningful conversations:
The participatory research mapping methodology transformed indigenous cognitive geographical knowledge into standard maps.[…] The approach recognized the interrelationships between the mental images in a person's head and the formal printed map […] intercultural exchanges and information sharing gave form to the maps and also gave them validity, authority, and power.
(Herlihy 2003).

At later stages of the research process, any of the visual methods discussed in previous sections can help the researcher to explore emergent theoretical insights. The page from Darwin's notebooks, in which the words "I think" are followed by his first-known sketch of an evolutionary 'Tree of Life', is a particularly famous example, but others can be found in many fields (Phipps, 2006).

Most researchers will have times when their thinking is 'stuck' or they feel they have reached a dead end. Using visual analogy to explore this situation can reveal unexplored avenues or identify insights previously unrecognised. Here the associative potential of collage is especially helpful (Butler-Kisma & Poldma, 2009)

Visual representations are also used to communicate research findings. Using more expressive modes alongside charts and standard graphical data can help generate new forms of knowledge and understanding, while enhancing students' ability to design conventional research posters.

An image can be a multilayered theoretical statement, simultaneously positing even contradictory propositions for us to consider. (Weber, 2008).

Final thoughts

We hope that the suggestions and examples in this brief outline will encourage you to consider incorporating drawing and other visual methods into your lectures, workshops and other teaching sessions. Our experience, and that of the colleagues with whom we have worked over the past few years, is that most students really appreciate the excitement and energy that comes with using active visual approaches in an academic context.

We would emphasise again that most of these do not need elaborate preparation, specialist materials or unlimited space and time. However, like any other teaching strategy, they benefit from thoughtful planning and selection of the most appropriate activities for each purpose, and sufficient time for discussion afterwards.

It is also worth spending a few minutes explaining the rationale for what you are asking students to do, so that they understand that what may seem like 'play' has a serious purpose. At the same time, aim for a relaxed atmosphere so that anxiety about perceived lack of drawing skill does not inhibit anyone's ability to participate fully.

Wherever possible, keep a record of drawing activities and the images produced, so that students can revisit these later. Digital technologies have made it very easy to take quick photographs and upload them to online sites or virtual learning environments (VLEs). Giving students the chance to do this for themselves aids their ownership of the process, Reviewing the images helps to re-activate memories of the session and reinforce students' learning, while printouts, with comments and other additions, can usefully be included in reflective journals or portfolios.

The website associated with these booklets contains more detailed descriptions and tips for running particular activities, along with downloadable materials, case studies and links to further reading and resources. We hope that you will these useful and will also contribute to future debates about the role of drawing in higher education by sending us your feedback and suggestions via the website **www.brighton.ac.uk/visuallearning/drawing**

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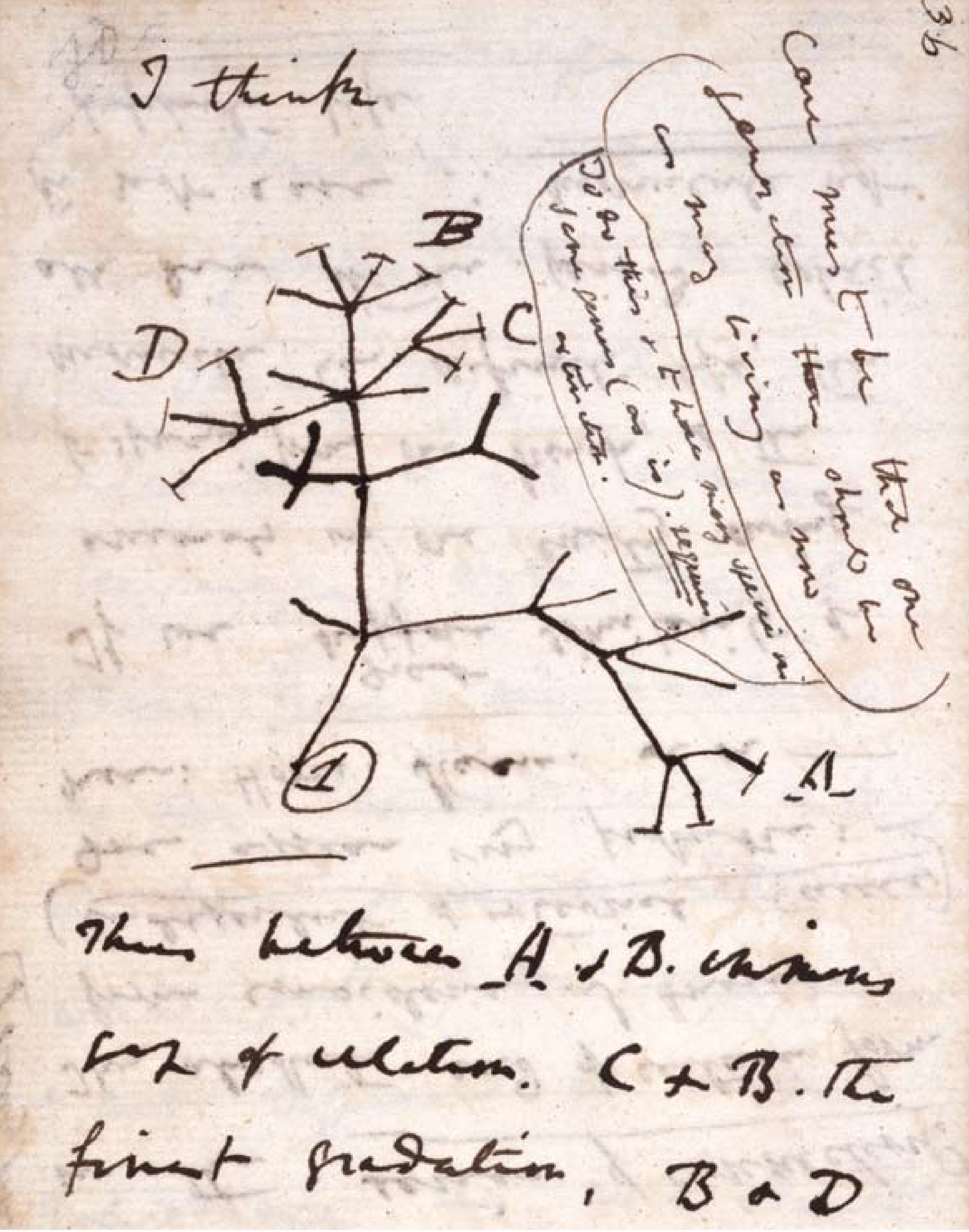

I think
1
A
B
C
D
Thus between A & B immense gap of relation. C & B the finest gradation, B & D