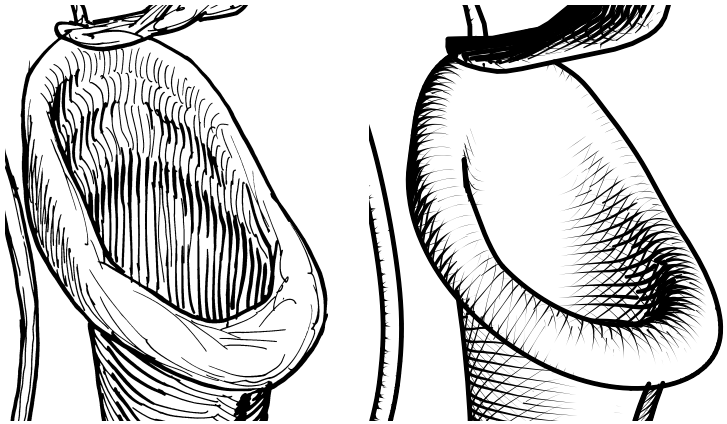
Non-Photorealistic Rendering in Context: An Observational Study

Tobias Isenberg
Petra Neumann
Sheelagh Carpendale
Mario Costa Sousa
Joaquim A. Jorge



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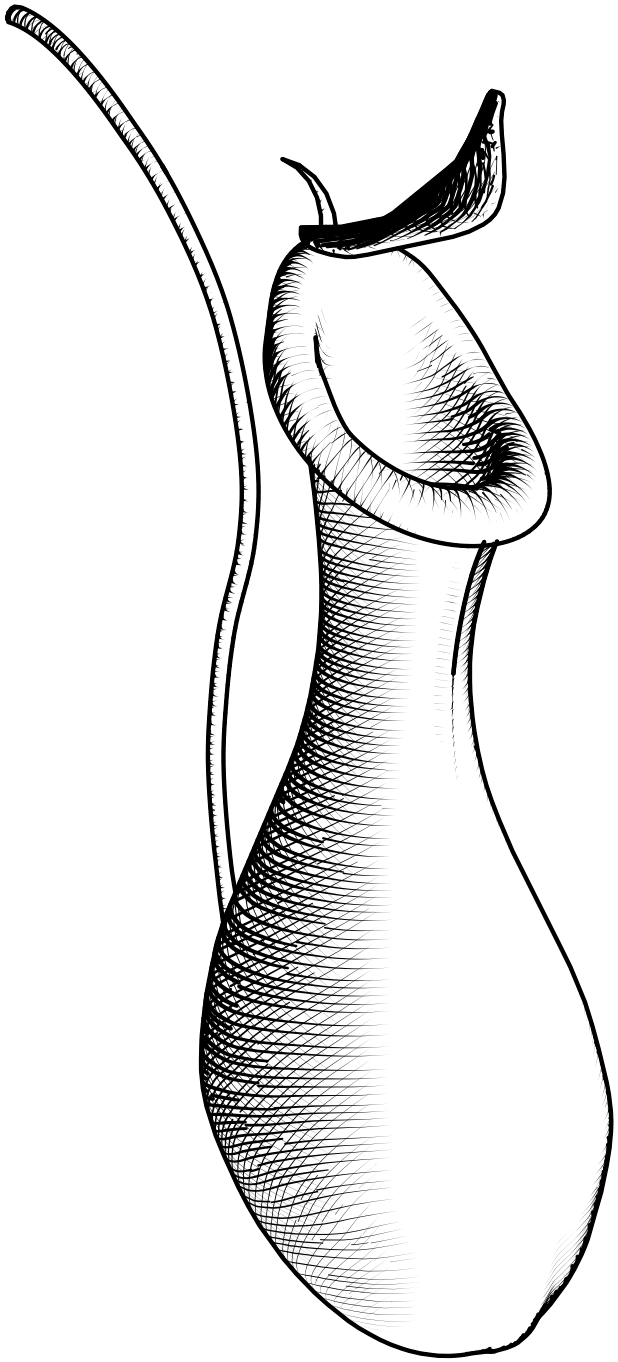
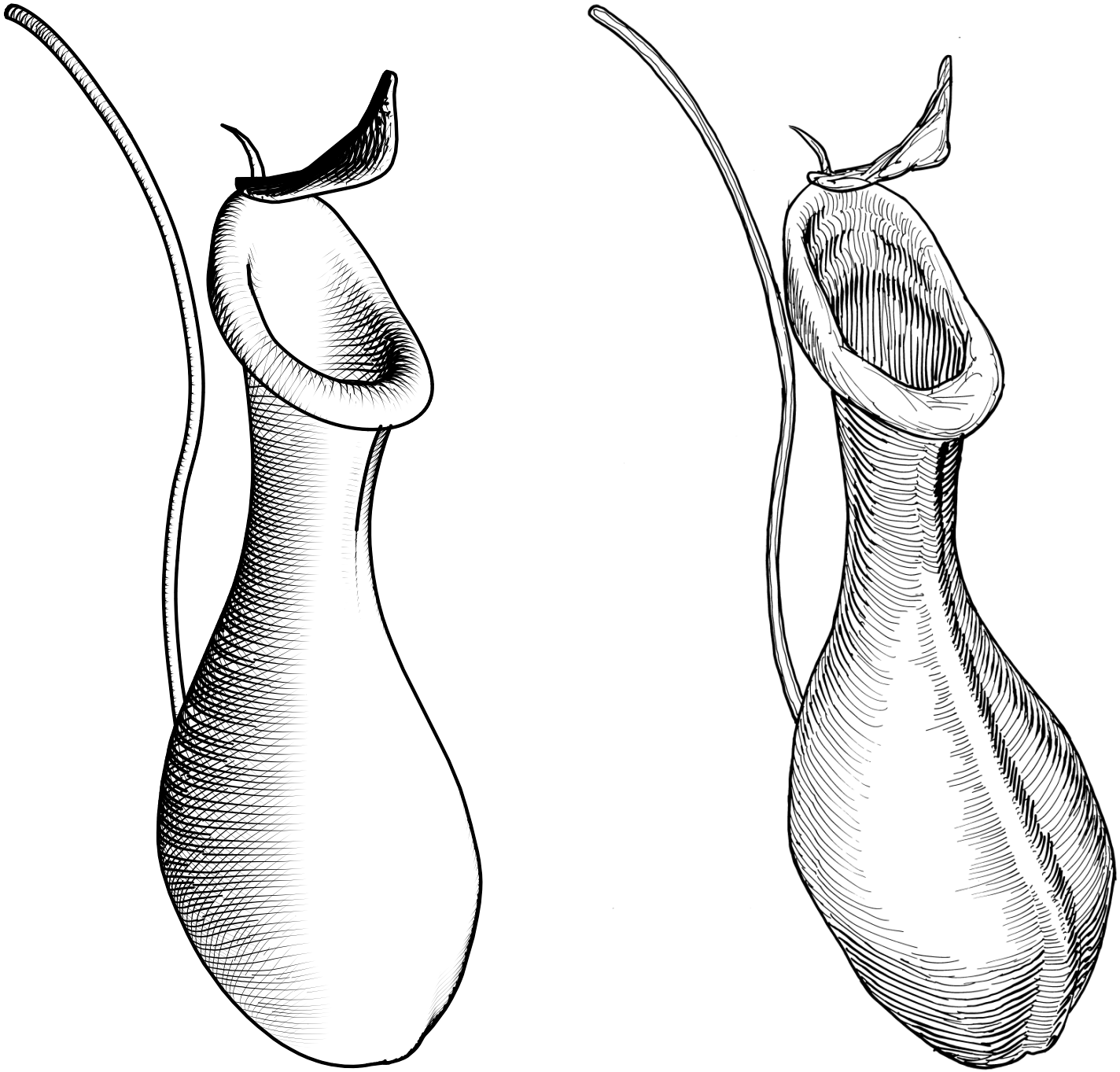


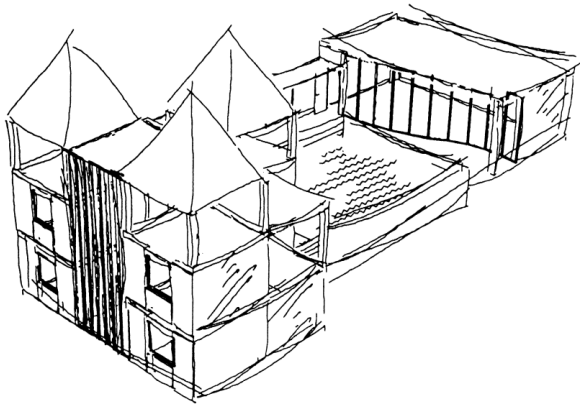


Introduction

- NPR inspired by artistic and illustrative depiction
- few evaluations of state-of-the-art
- comparative study of hand-drawn and NPR illustrations
- restriction to scientific illustrations
- restriction to pen-and-ink styles
- qualitative study

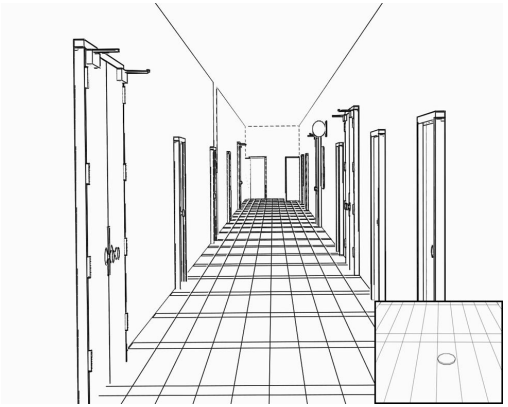
Related Work

NPR in architecture



[Schumann et al. 1996]

space perception



[Gooch and Willemsen 2002]

psychology of NPR

[Duke et al. & Halper et al. 2003]

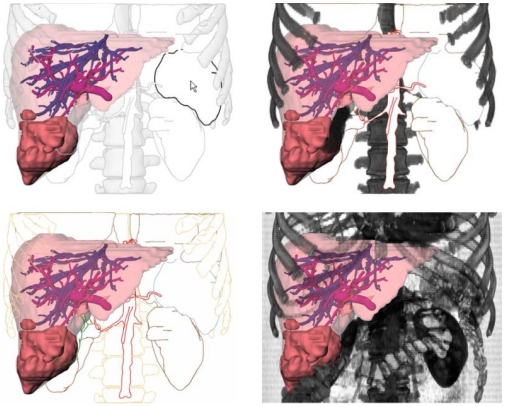
influence on gaze direction

[Santella and DeCarlo 2004]

facial illustration

[Gooch et al. 2004]

medical visualization



[Tietjen et al. 2005]

Study Rationale

- viewing/evaluating/understanding illustrations: complex process, difficult to analyze

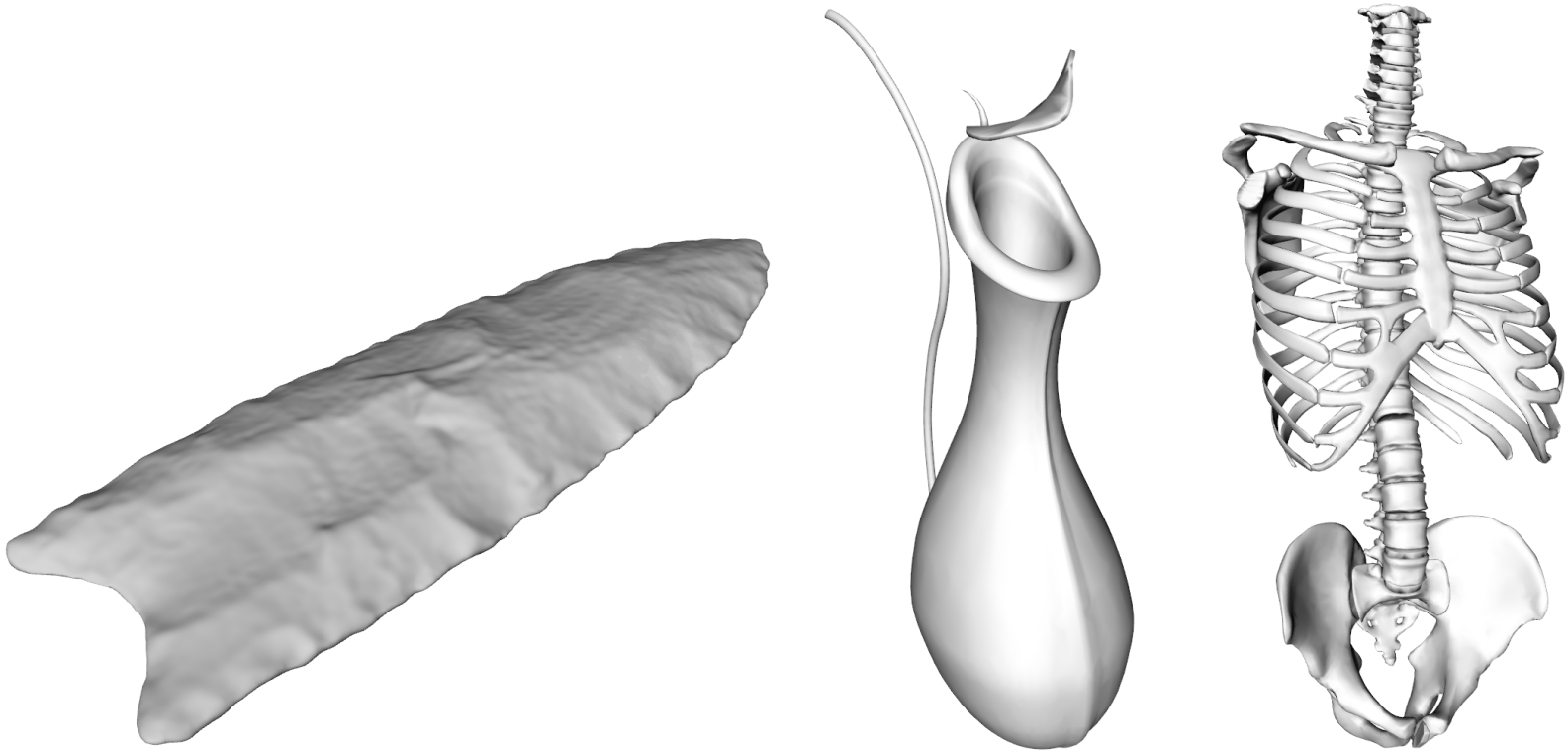
- exploratory observation:
  - no predetermined hypothesis
  - ethnographic technique: pile sorting
  - criteria & terminology determined by participants
  - important goal: not to bias participants

- observing participants' actions & opinions

- qualitative results

Study Setup: Images

- 30 images of 3 "models" generated: archaeological, botanical, and medical model



- 5 professional illustrators and 5 NPR algorithms

Study Setup: Professional Illustrators

- William M. Andrews:
  hatching or stippling w/ silhouettes
- Davide Brunelli:
  sketchy hatched outlines
- Humberto Costa Sousa Filho:
  silhouette, scratchboard w/ hatching
- Andrew E. B. Swift:
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- Lynda Smith Touart:
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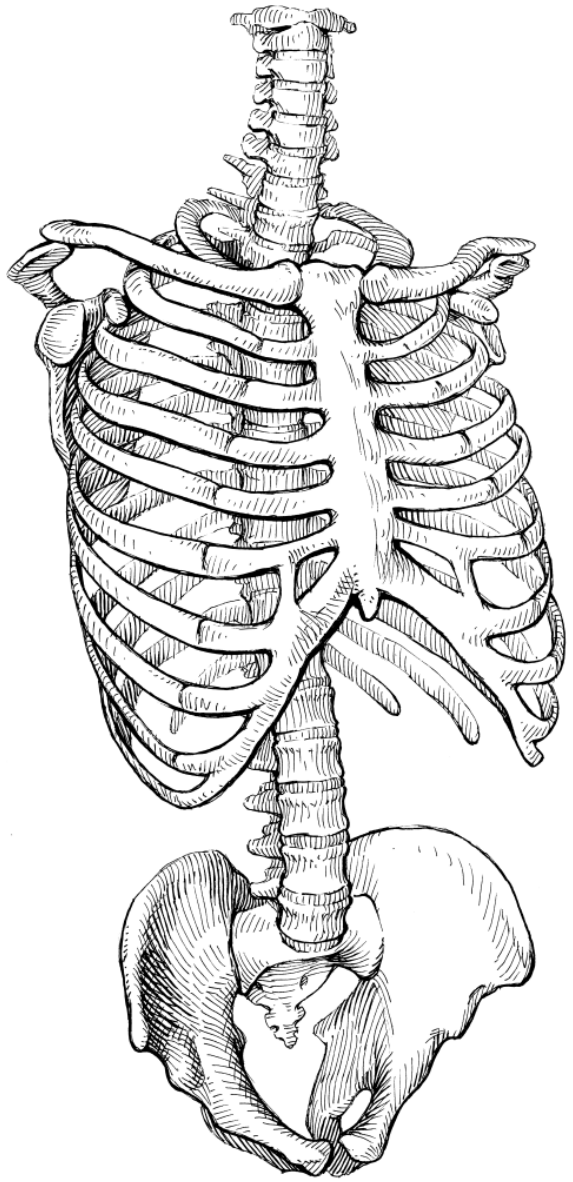

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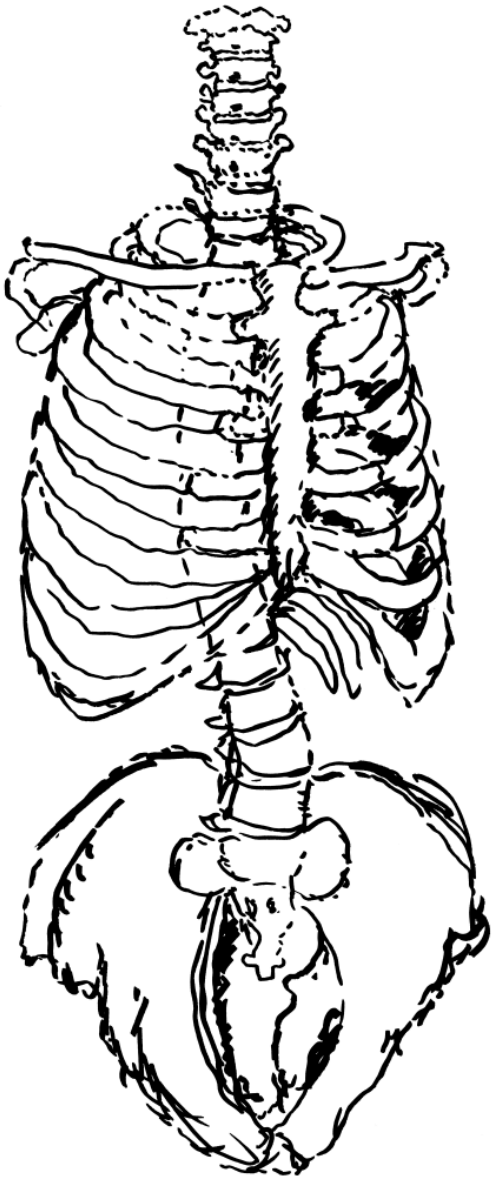

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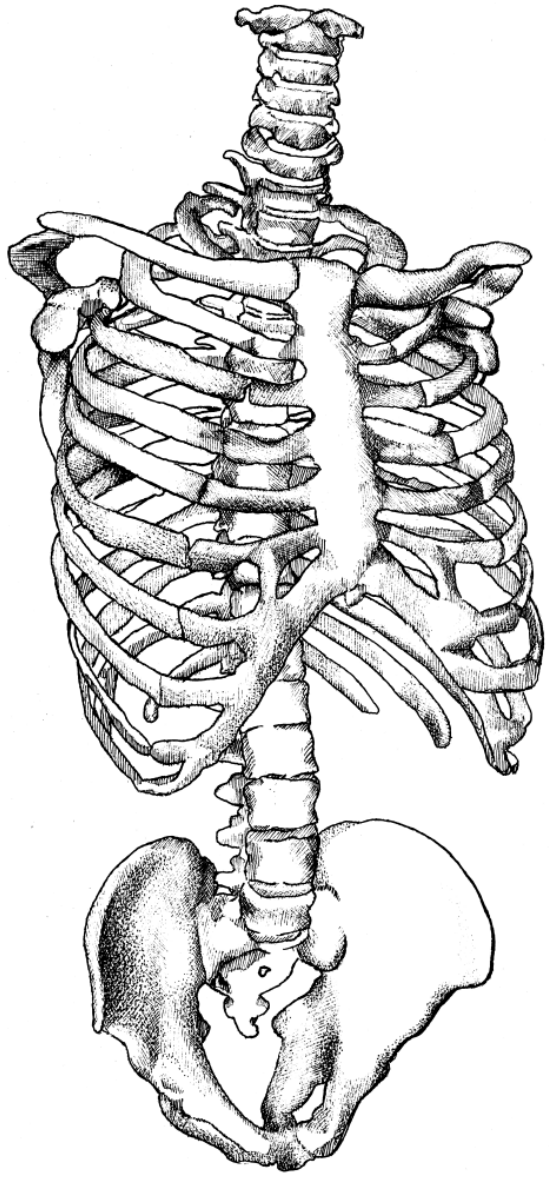

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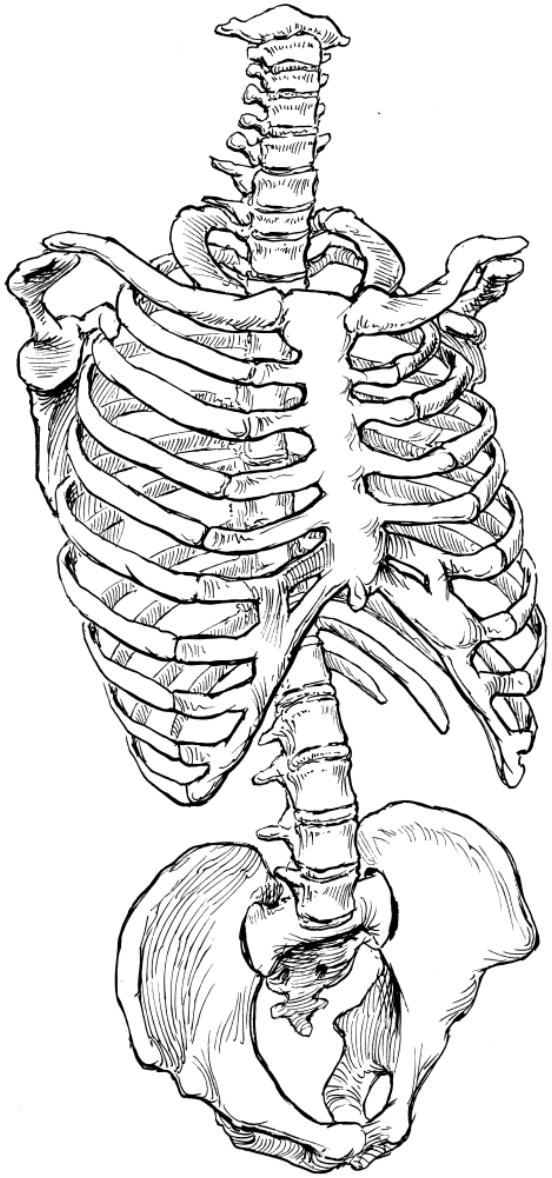

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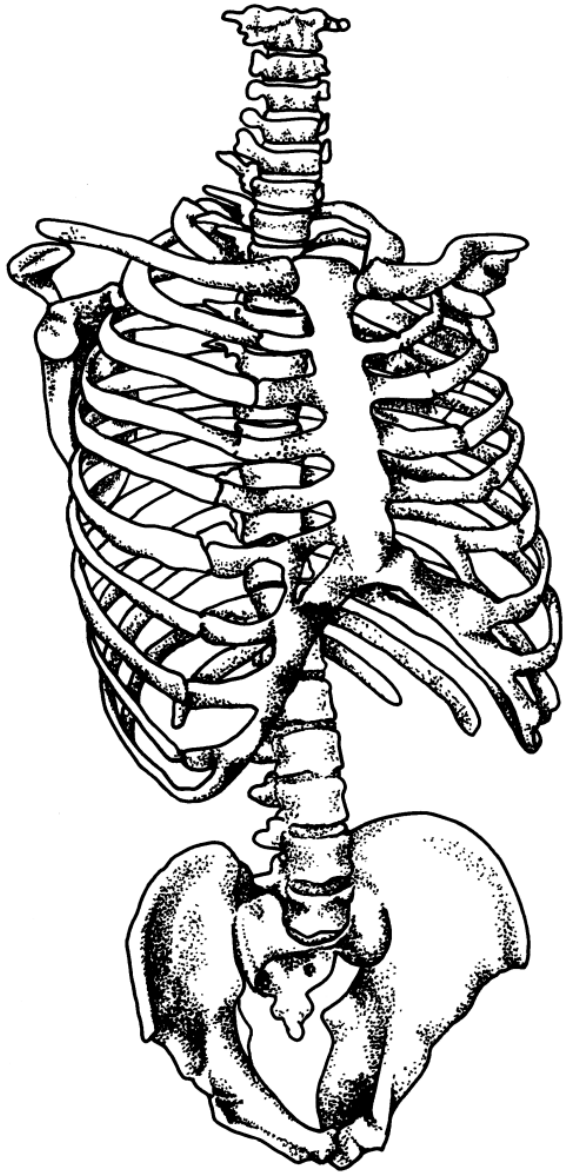

Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]:
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- [Sousa et al. 2003 & 2004]:
  precise ink marking
- [Zander et al. 2004]:
  cross-hatching with silhouettes
- [Schlechtweg et al. 2005]:
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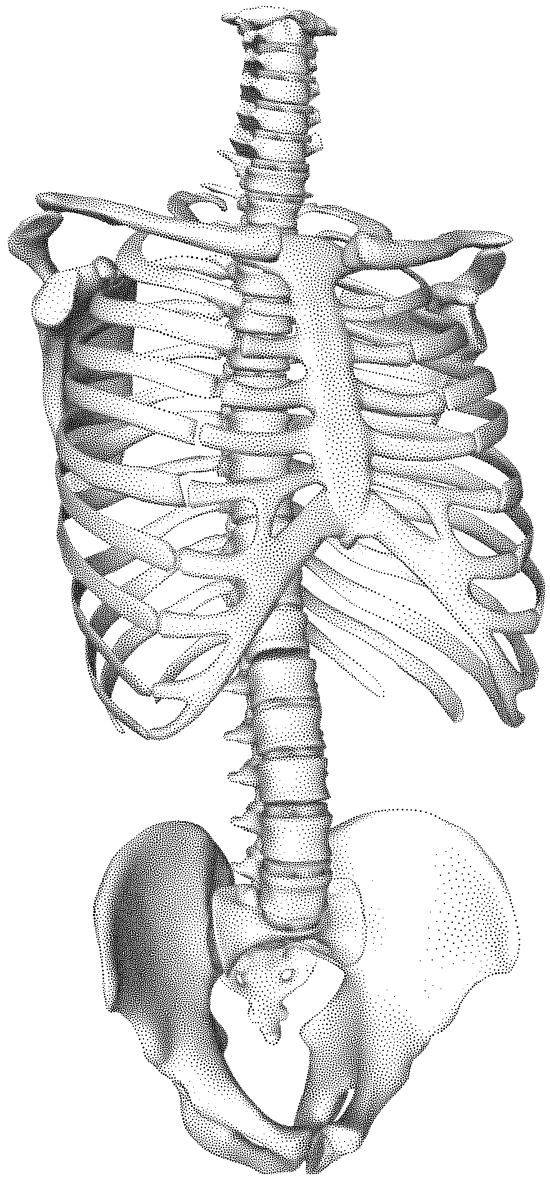

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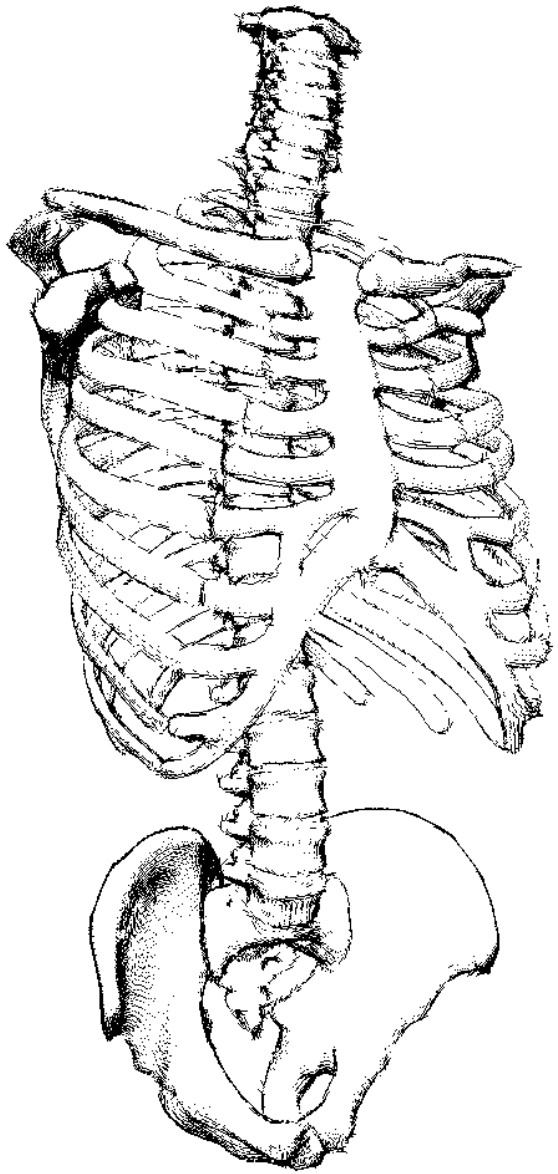

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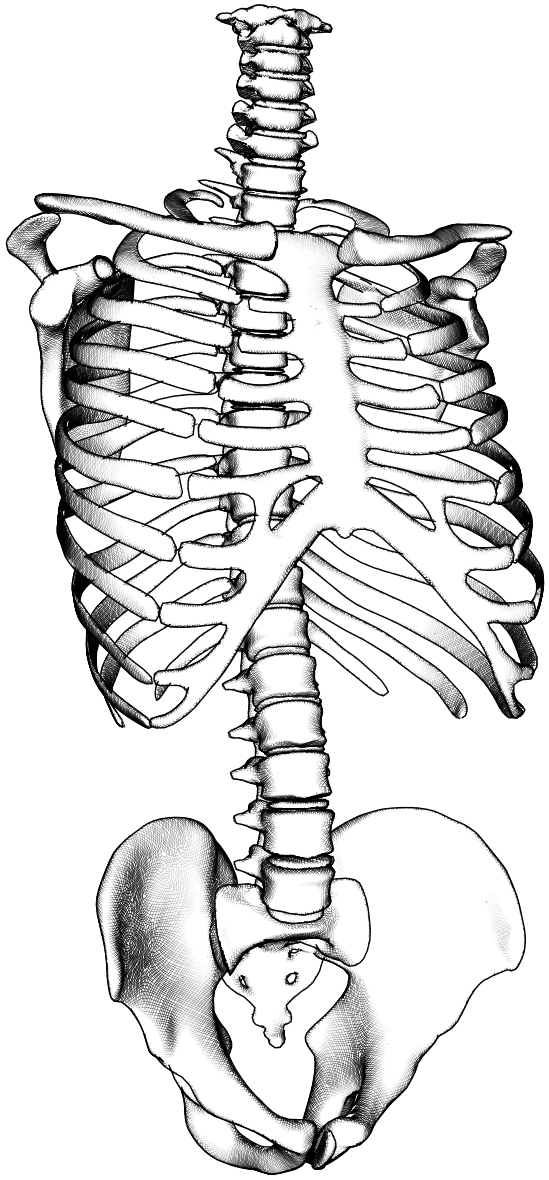

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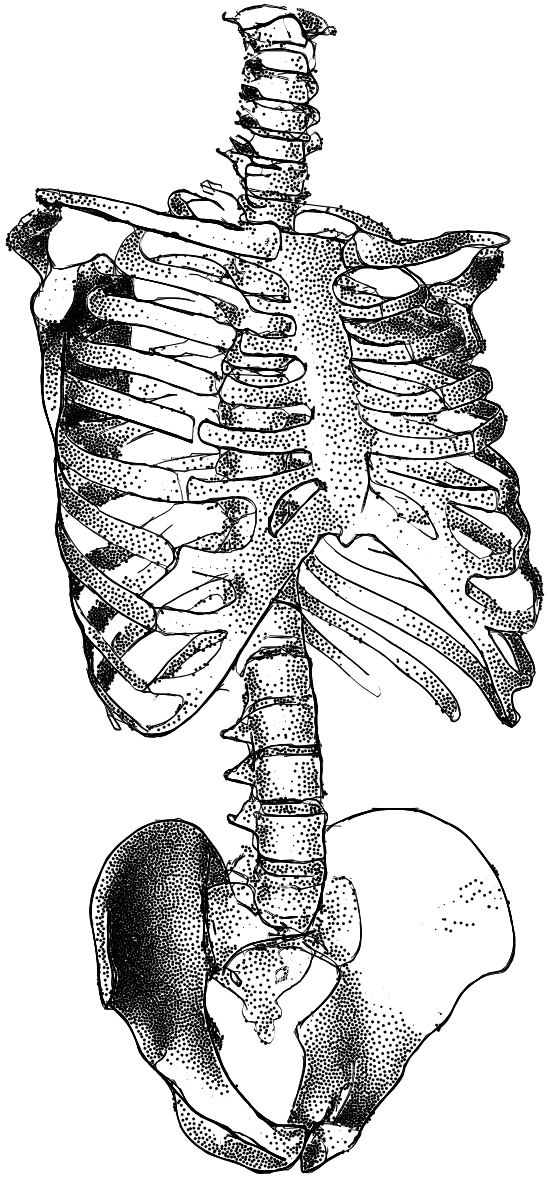

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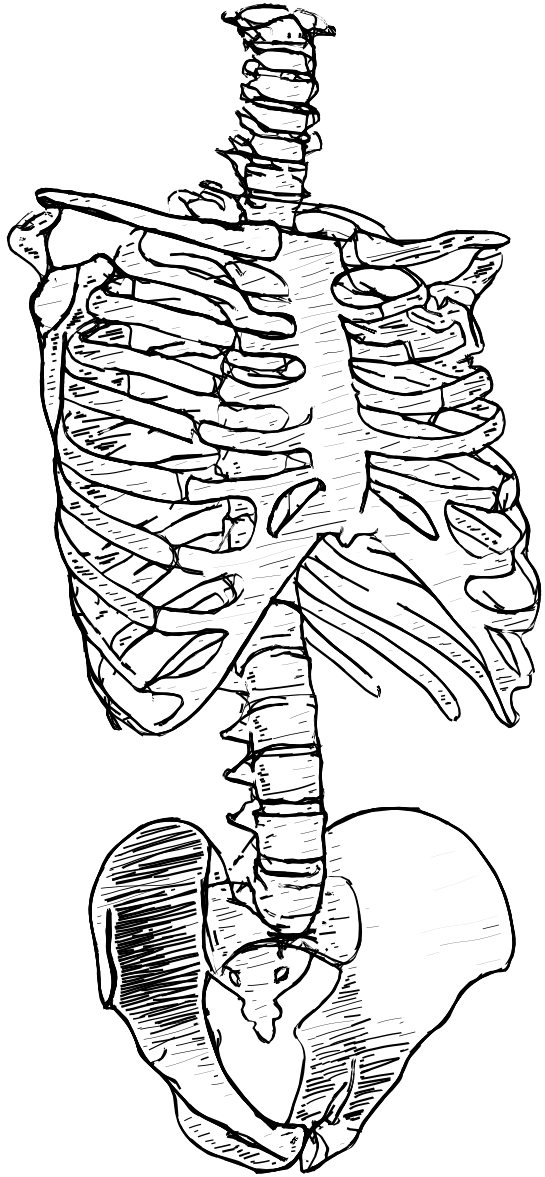

Study Setup: Participants

- four main groups:
  1. domain experts:
     scientists etc. who know their field
  2. professional illustrators:
     know how to make good illustrations
  3. illustration end users:
     learn with the produced illustrations
  4. NPR researchers:
     develop methods to produce illustrations with computers

- in our study: groups 2–4; mainly graduate students

- 8 participants per group; $\sum$ 24 participants

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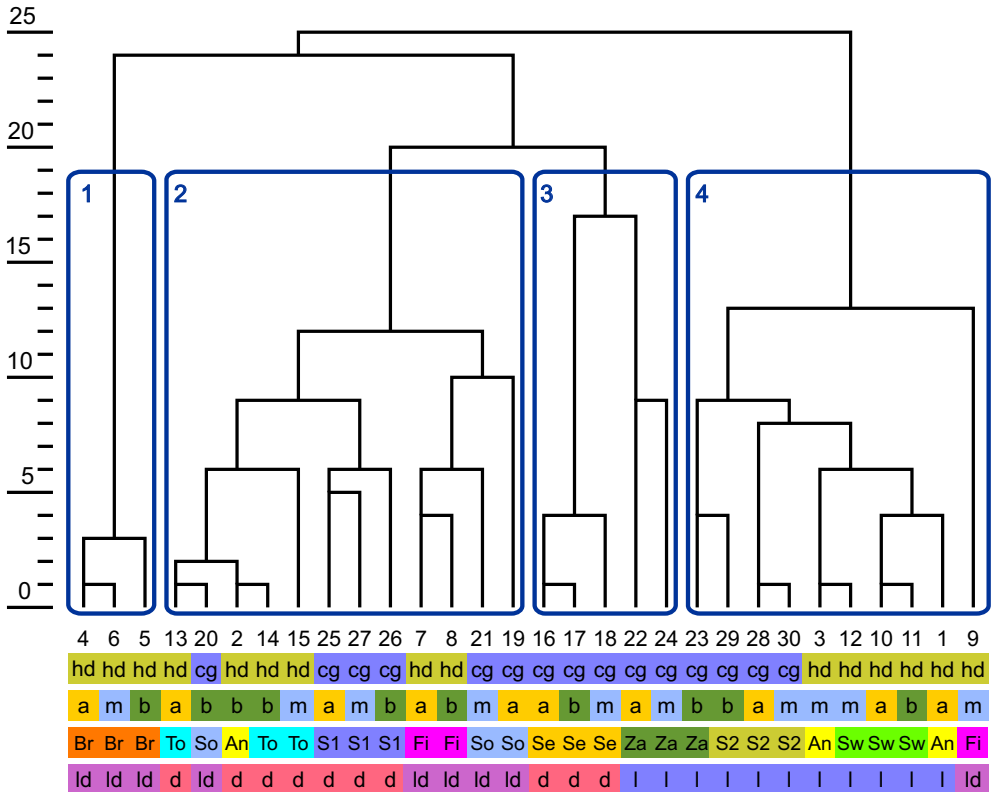
Study Setup: Procedure

- about 1 hour or less for each session
- three stages
  1. unconstrained pile-sorting:
     grouping objects,
     free choice of criteria
  2. semi-structured interview:
     discussion of the piles
     and predefined questions
  3. post-session questionnaire:
     demographics and
     previous experiences

- data acquisition through video and note taking

Results

- categorization by drawing/rendering style by most people
- less often used criteria: realism/detail, aesthetics, information contents, and orientation
- no significant differences between how the three groups categorized
- cluster graph from correlation table



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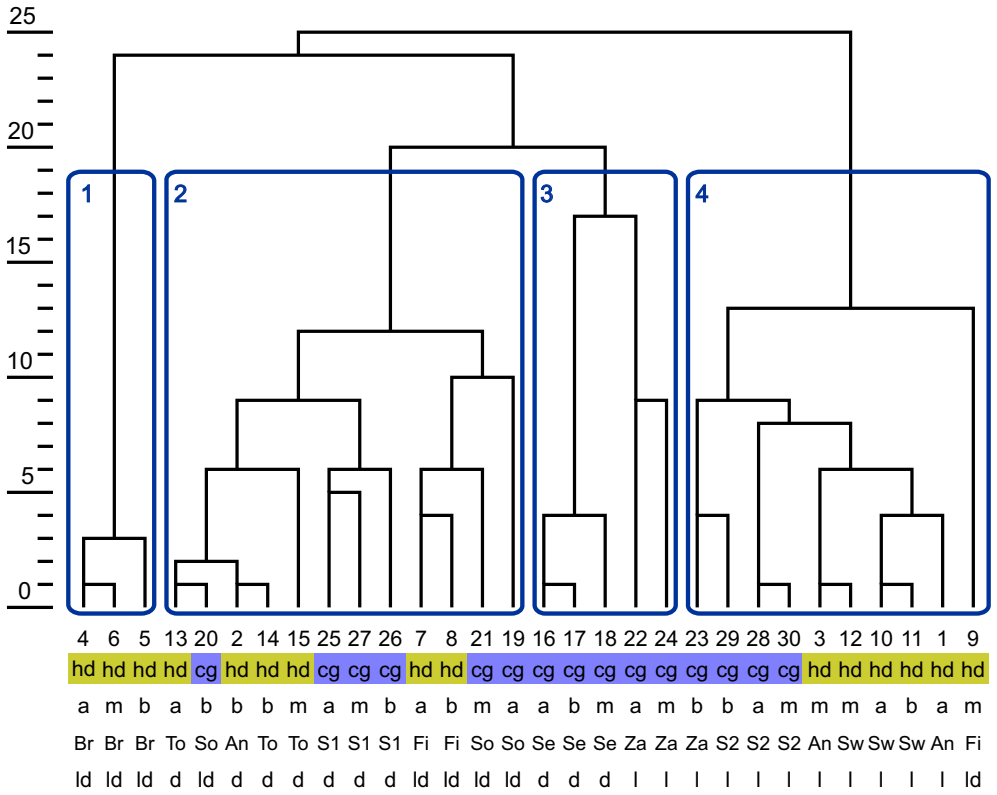

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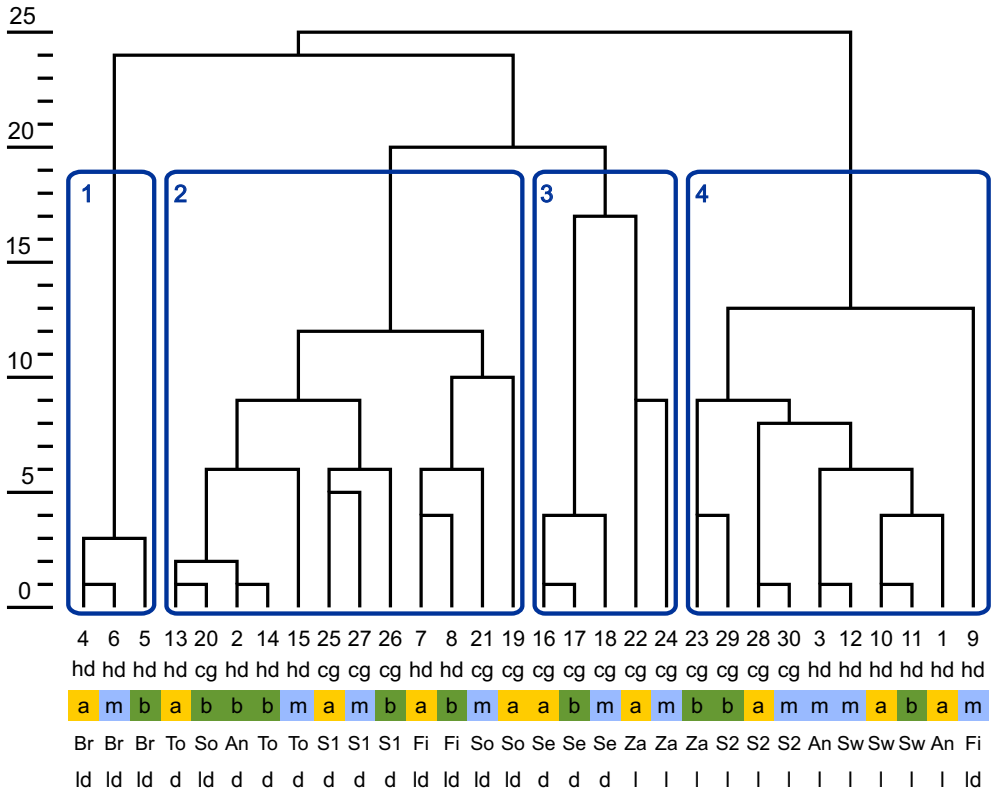

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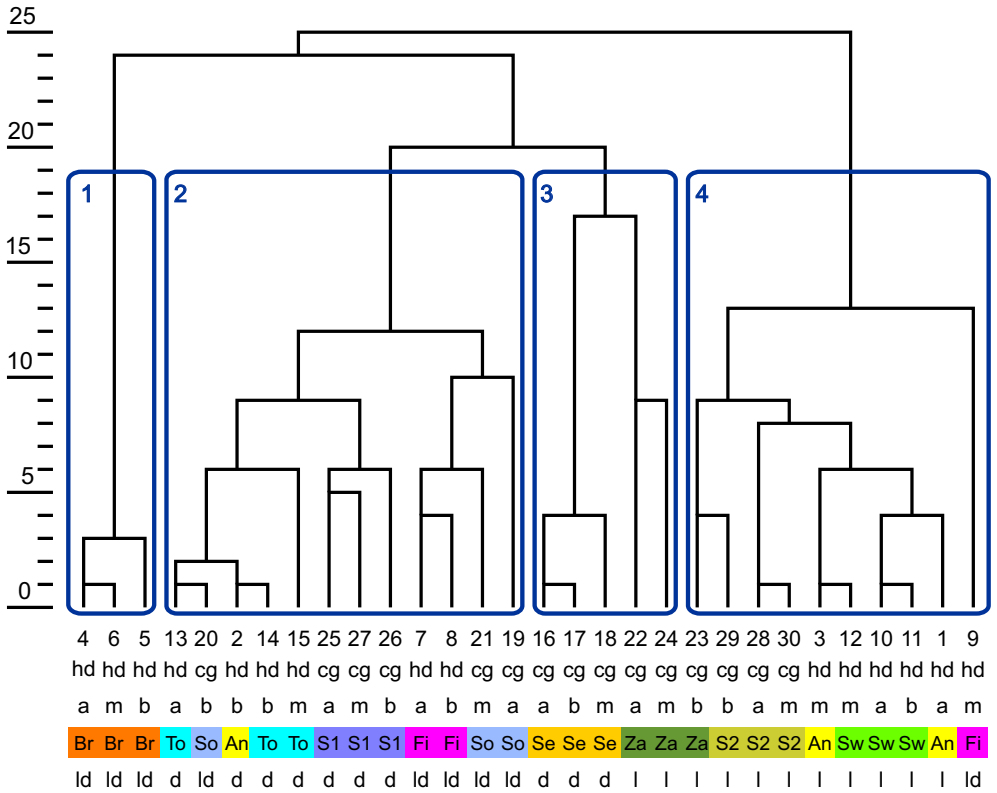

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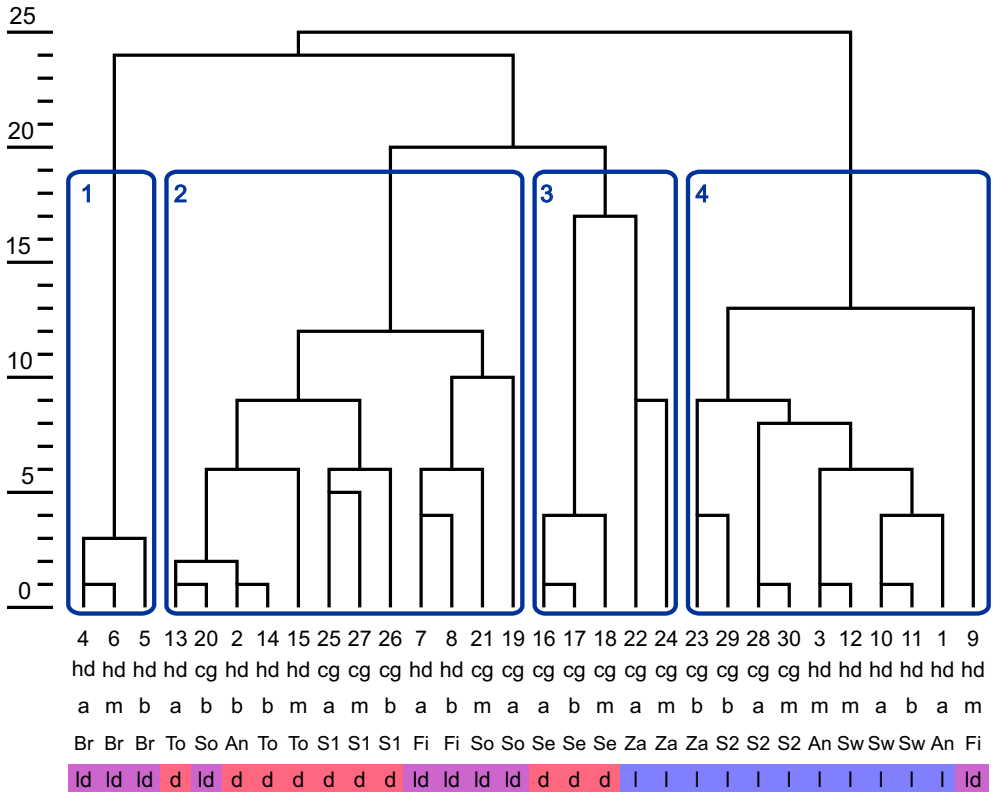
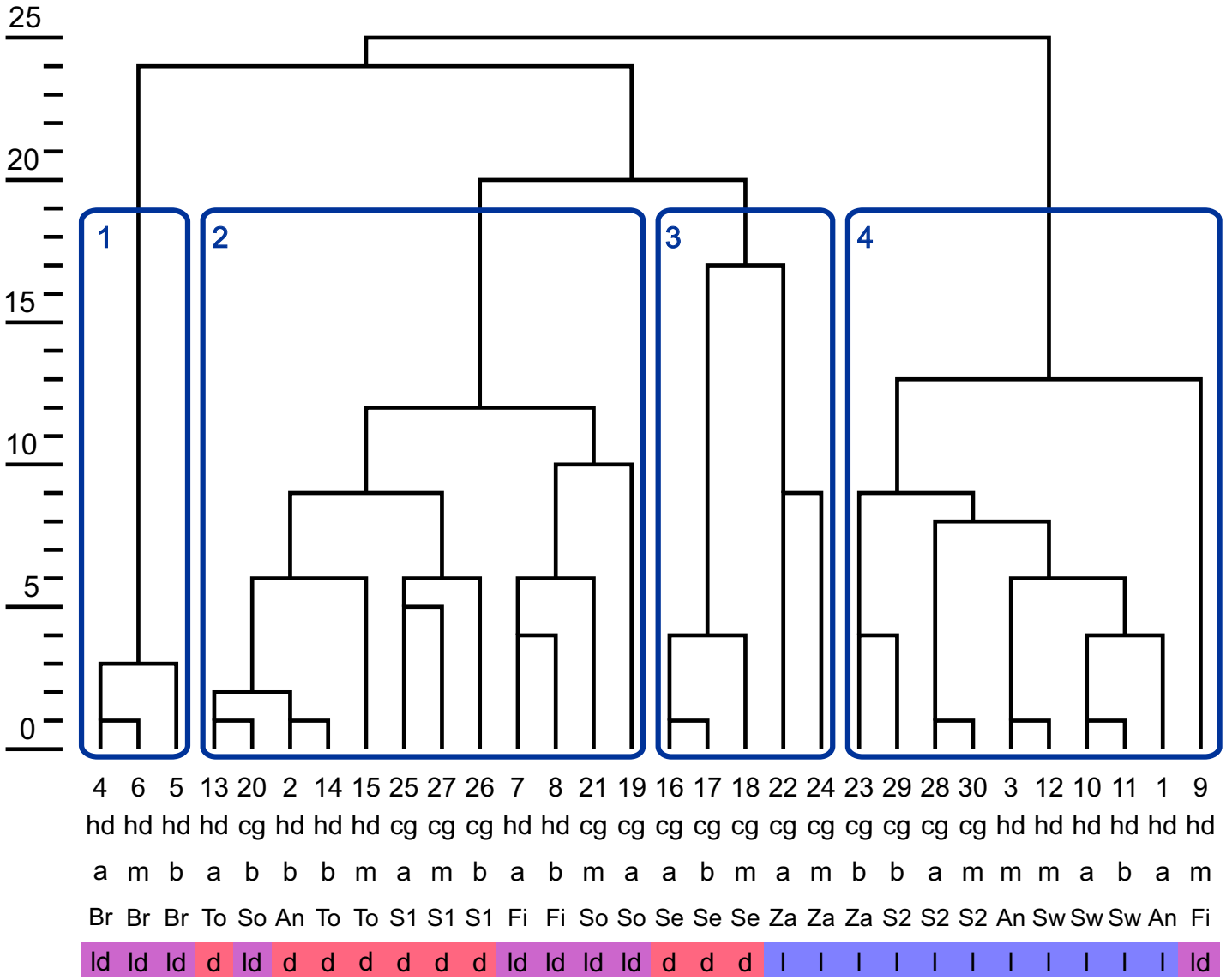
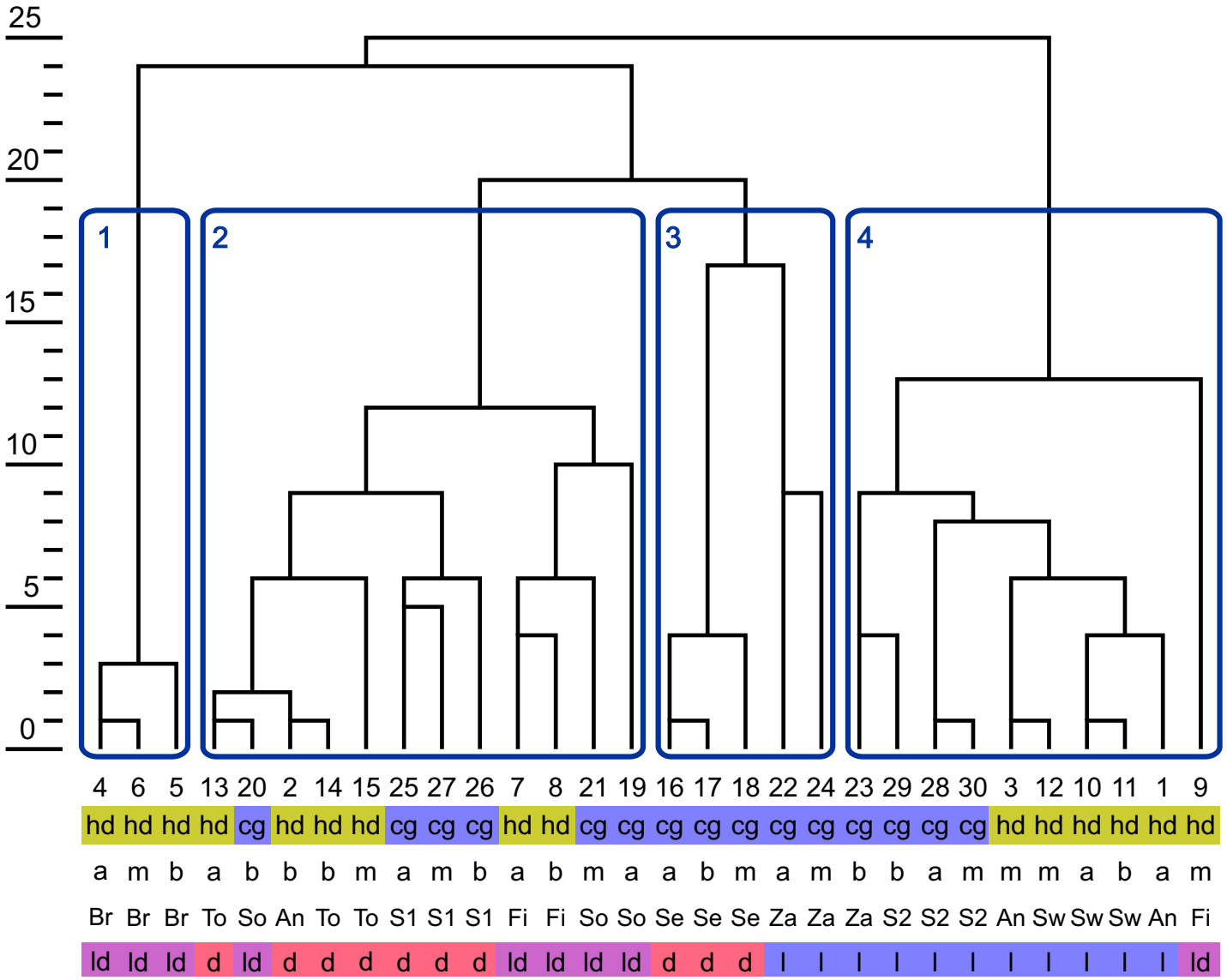


Discussion: pile-sorting to facilitate open discussion

Discussion: categories by style (hatching vs. stippling)



Discussion: amount of detail important (Cluster 3)



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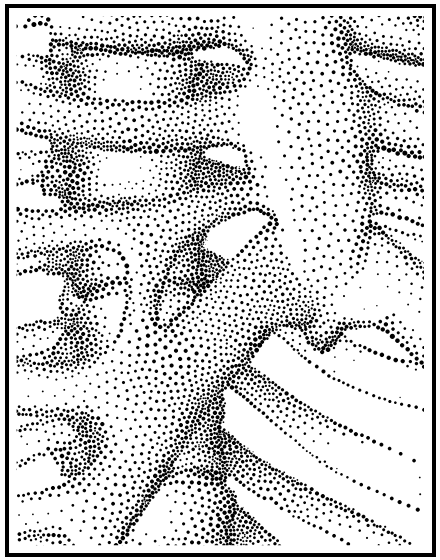
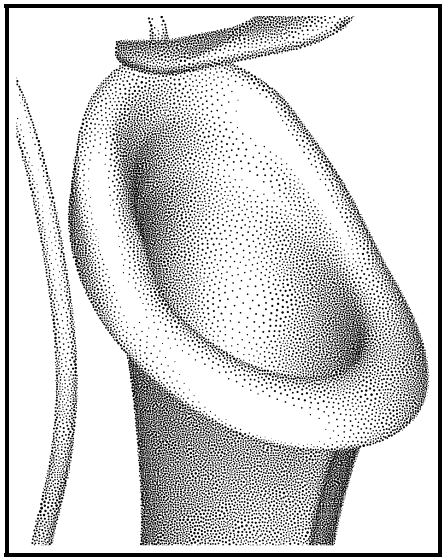
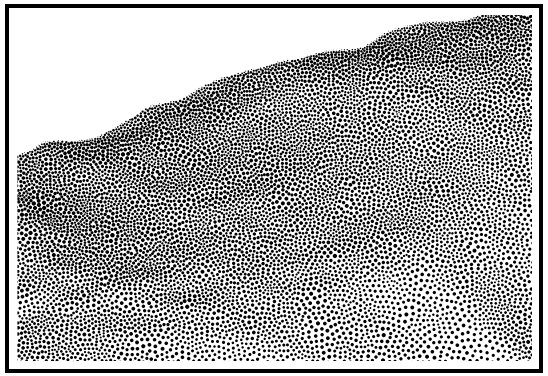
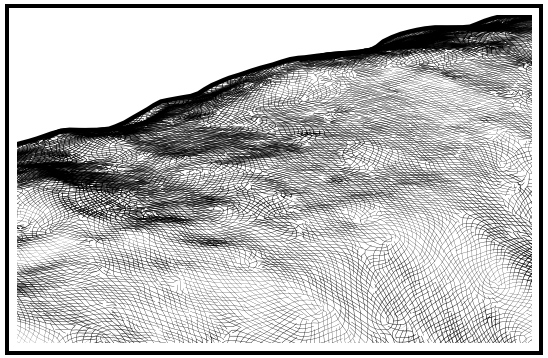
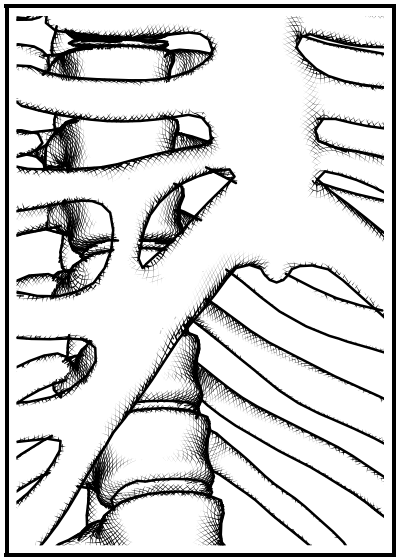
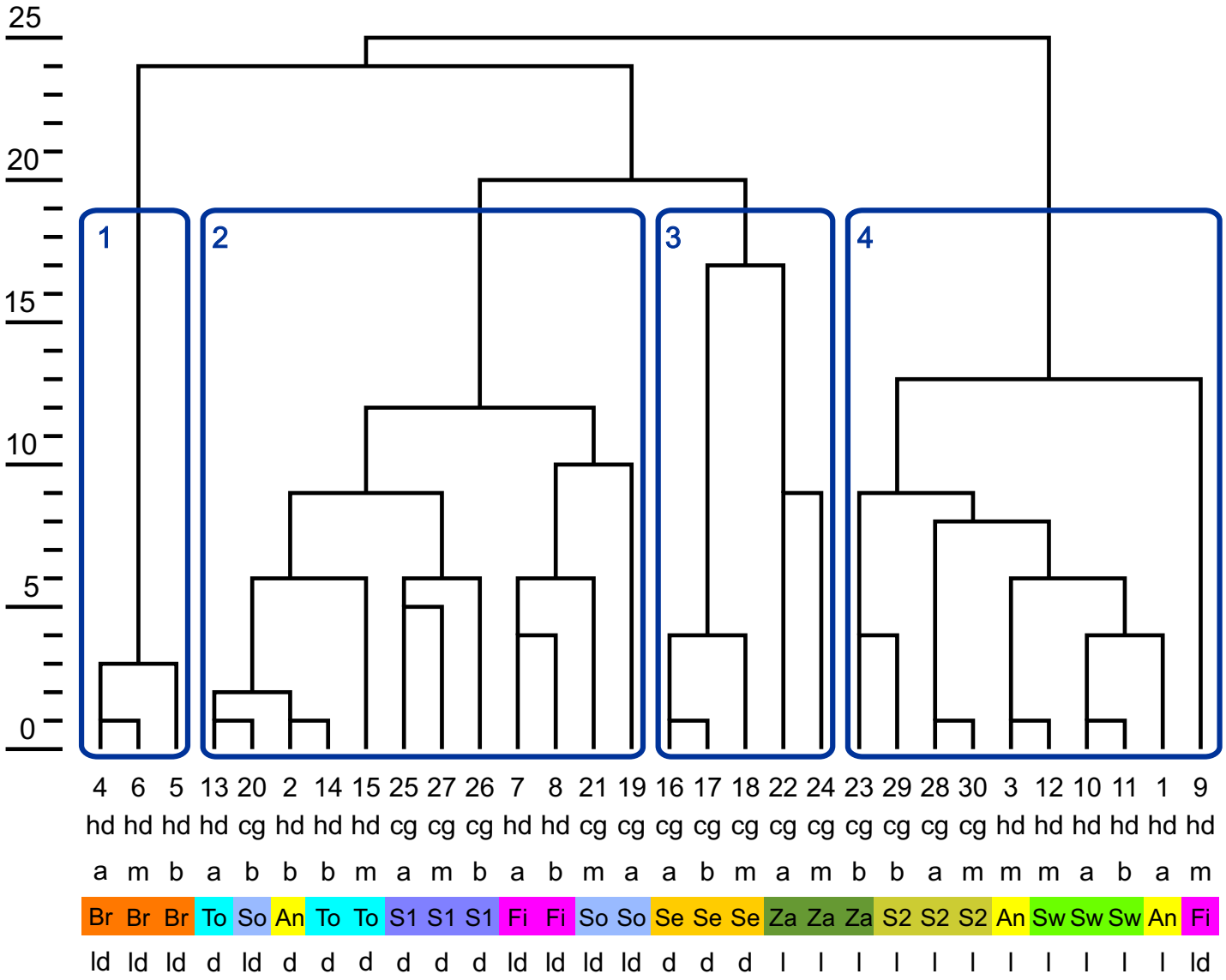
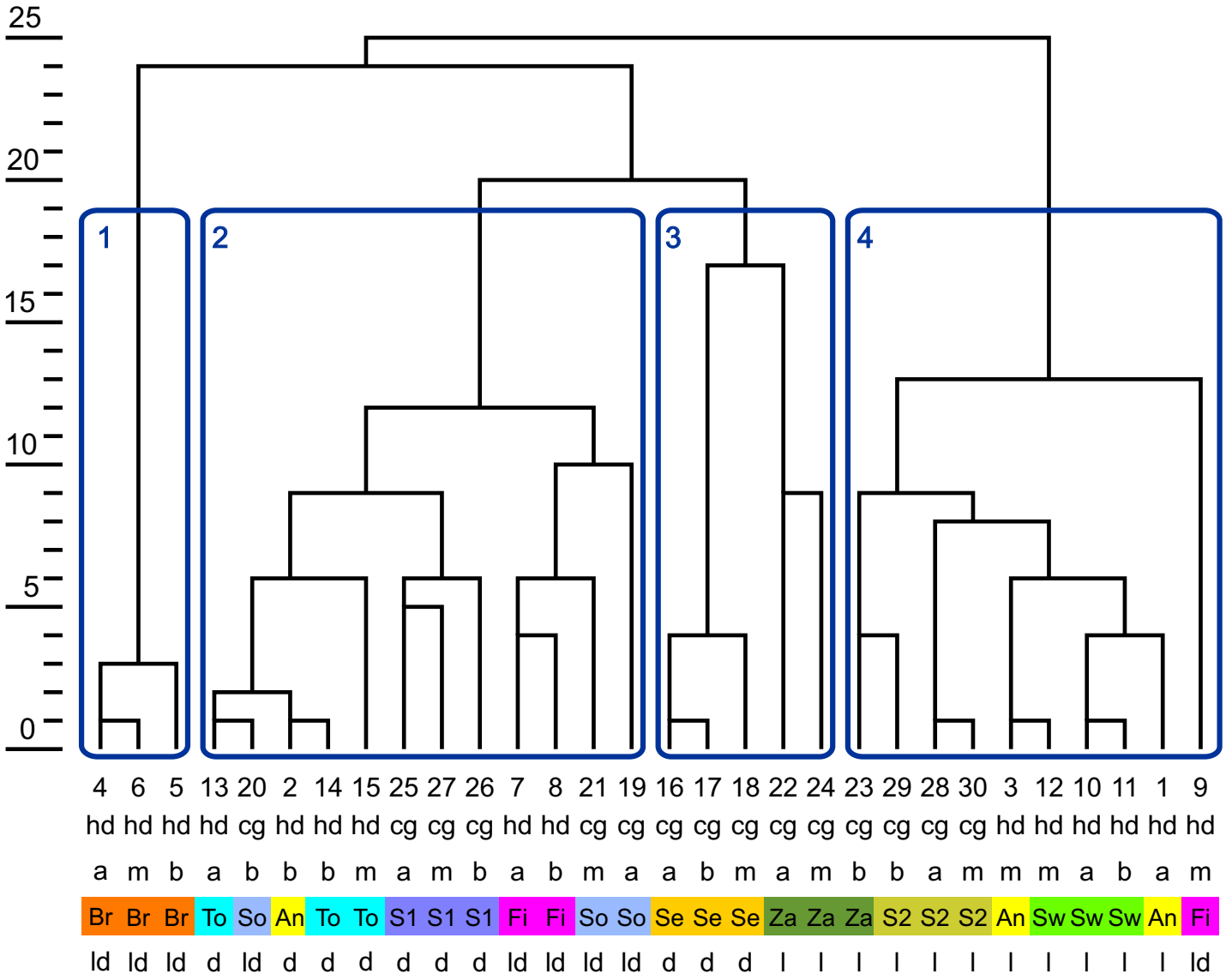






Discussion: some categorization by artists/algorithm



Discussion: Cluster 1: very distinct style—loose and sketchy



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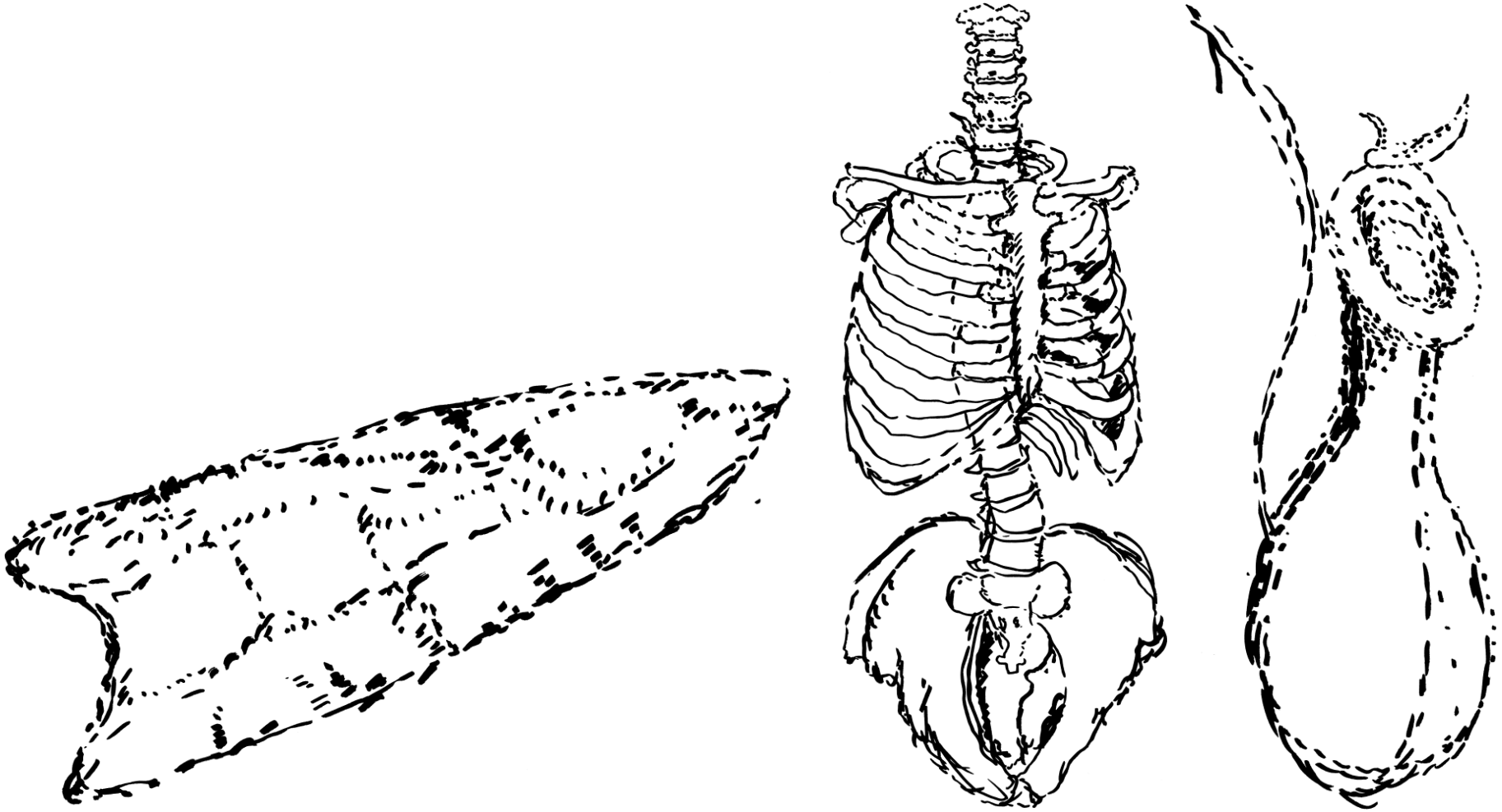
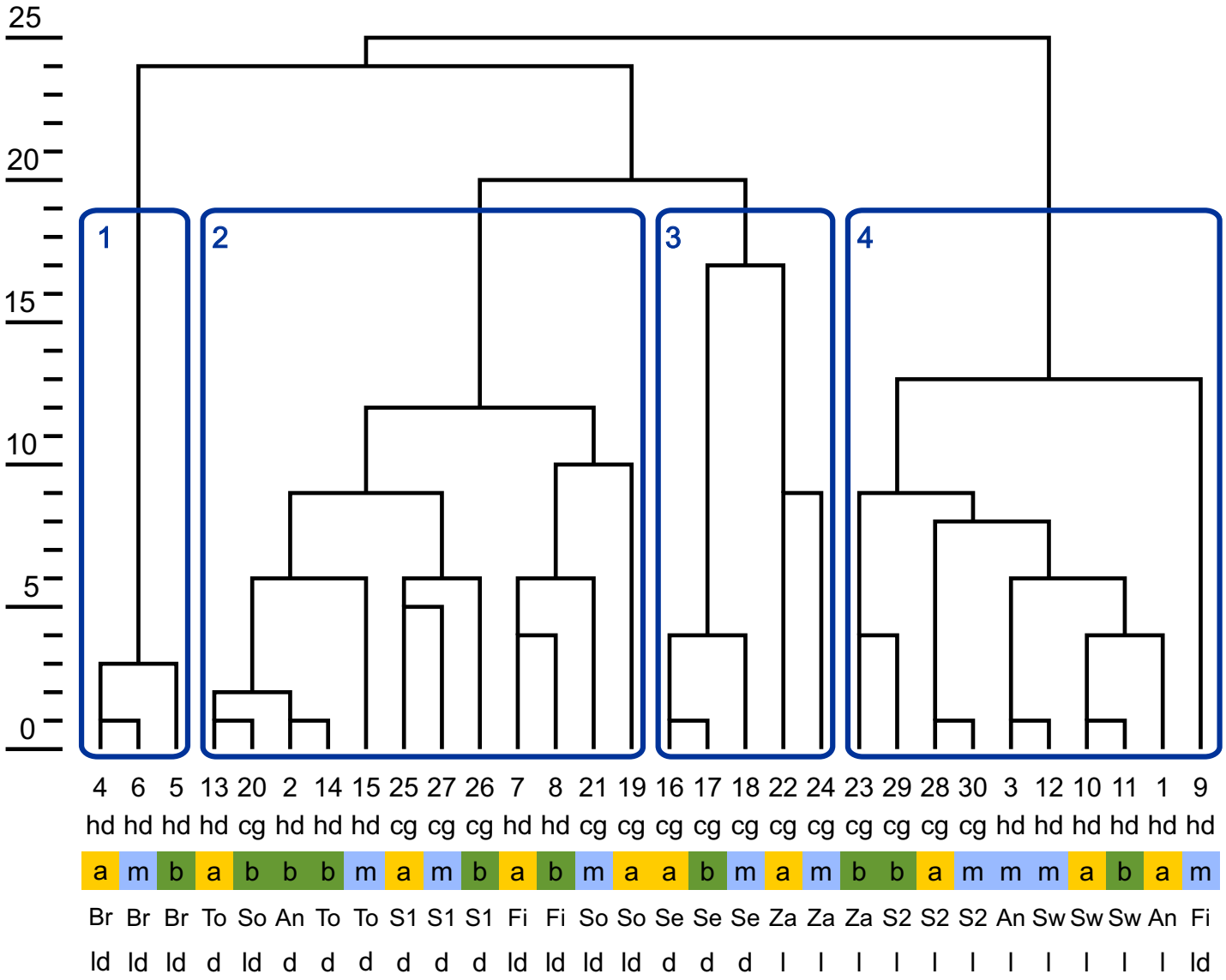


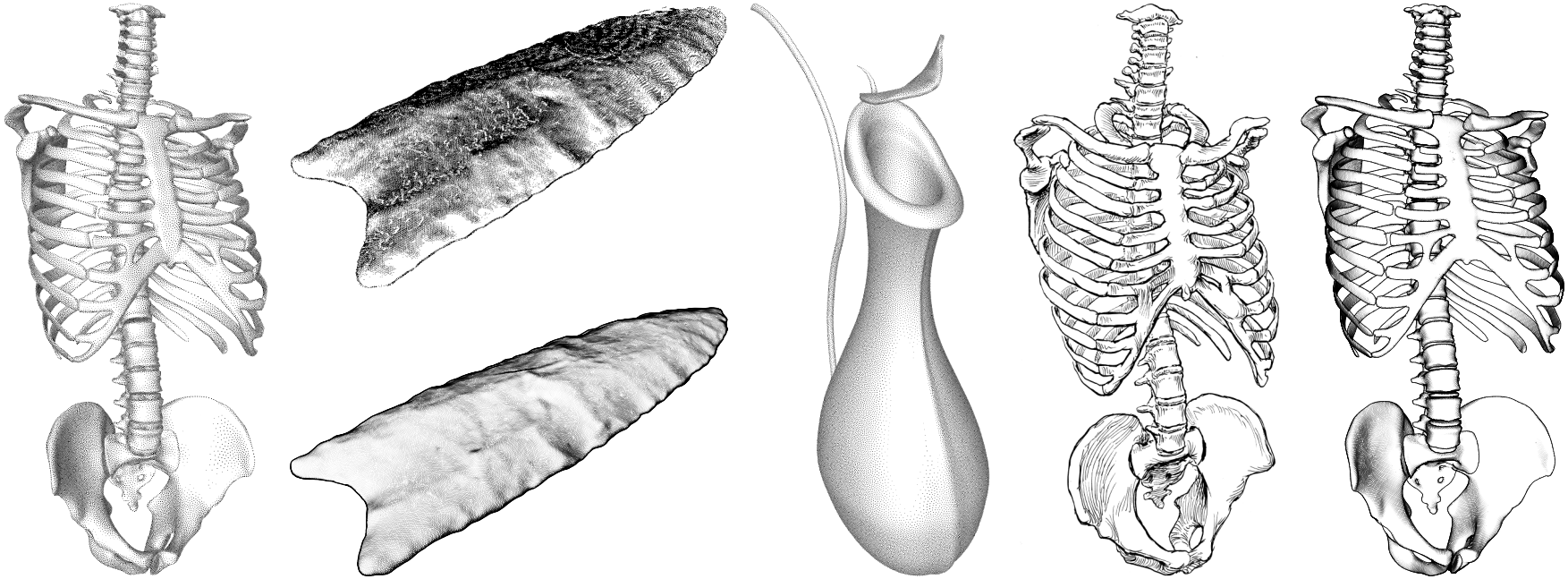
Discussion: no clustering w. r. t. model



Possible contexts for images

- science & art textbooks, in classes & museums, other publications, also art displays, comics, games & software

- usage in university textbooks:



- children's textbooks: more hand-drawn; conflicting opinions

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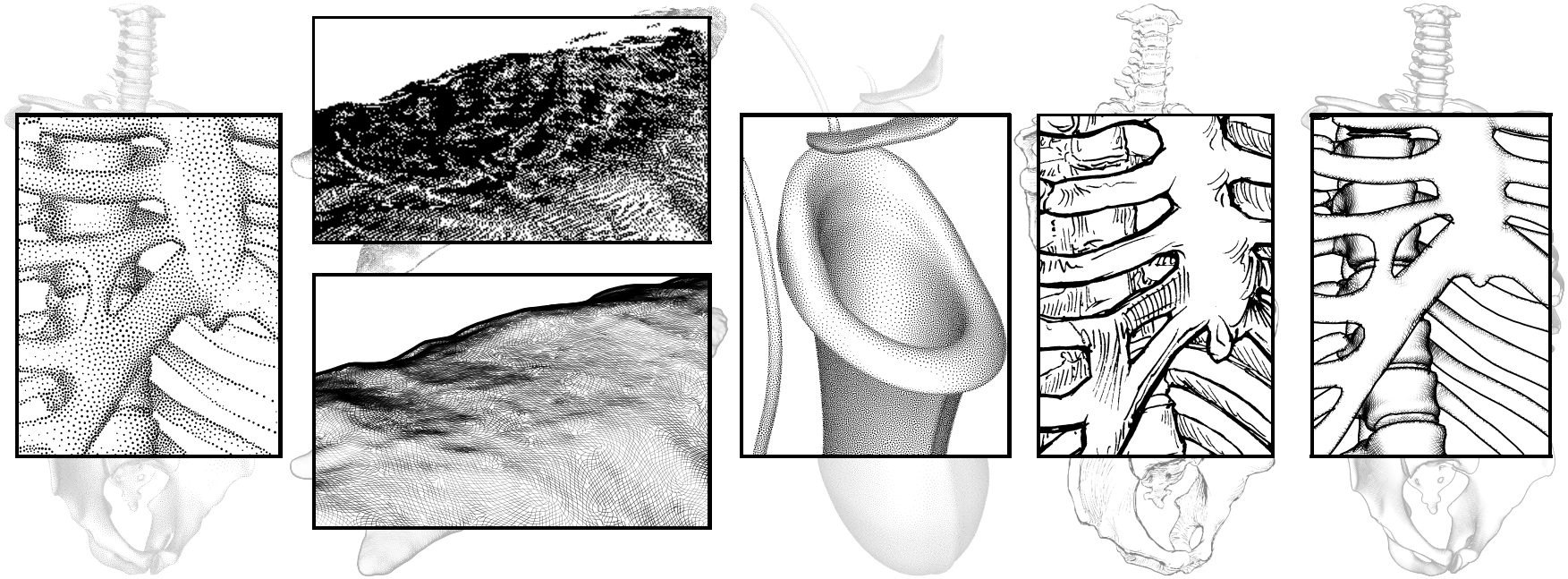
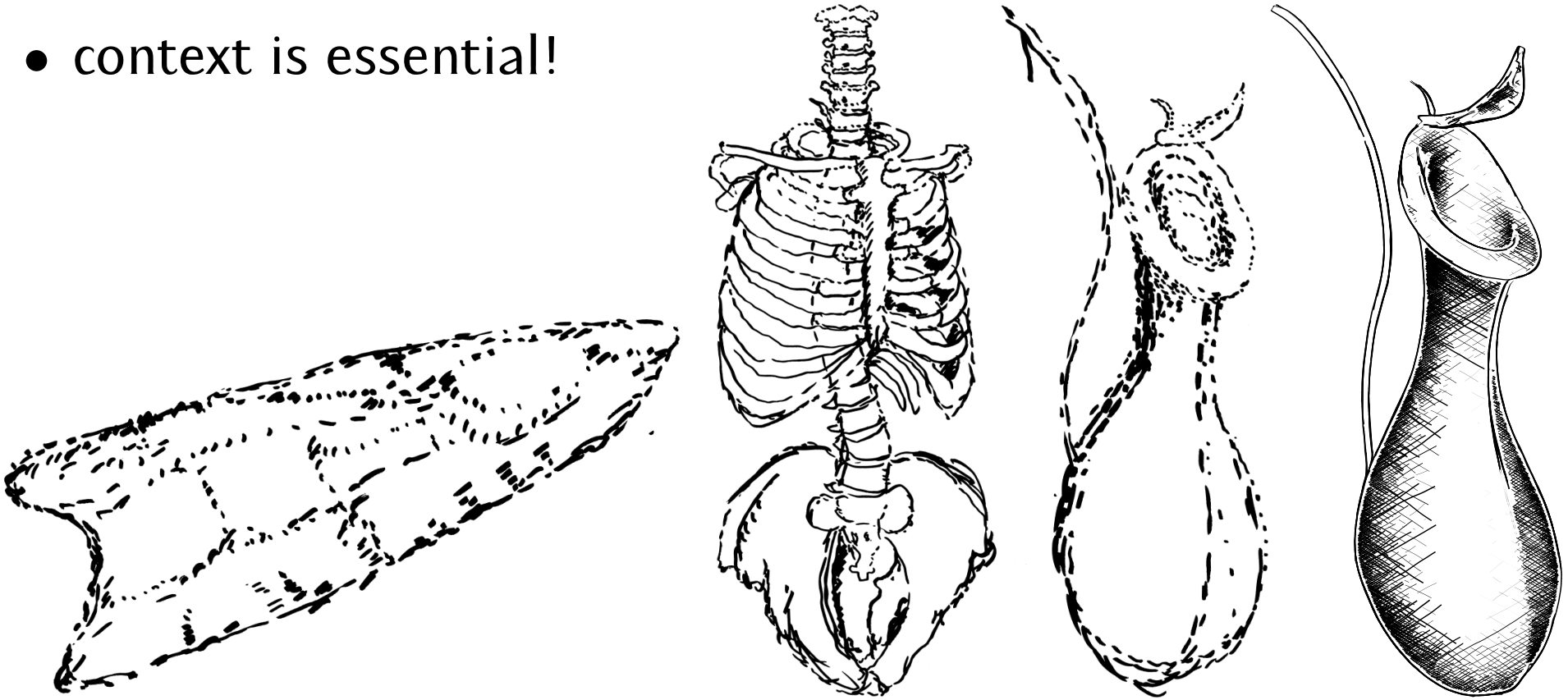


- children's textbooks: more hand-drawn; conflicting opinions

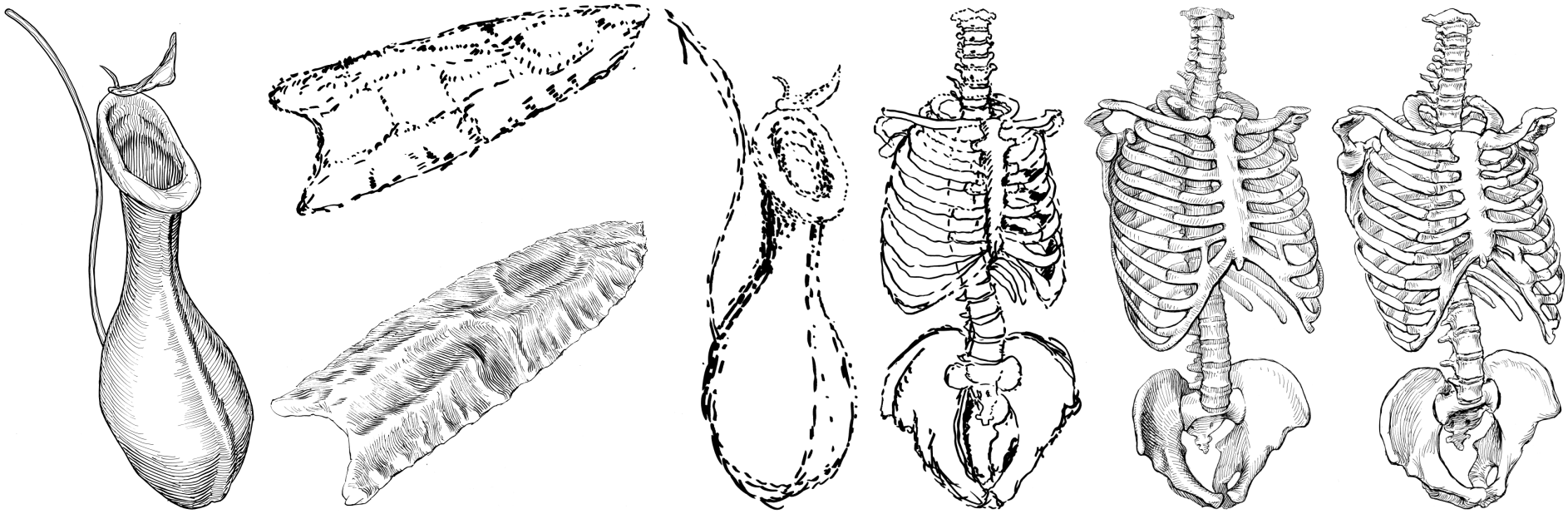
Image liking and appeal

- no clear favorites
- least favorites (named by $\geq 58\%$, all others $\leq 25\%$):
- context is essential!



Images looking most CG or hand-drawn

- many hand-drawn images stood out as such—lines:



83% 83%/71% 79% 79% 67% 58%

- hand-drawn images less often named: stippling or mix of stippling with lines

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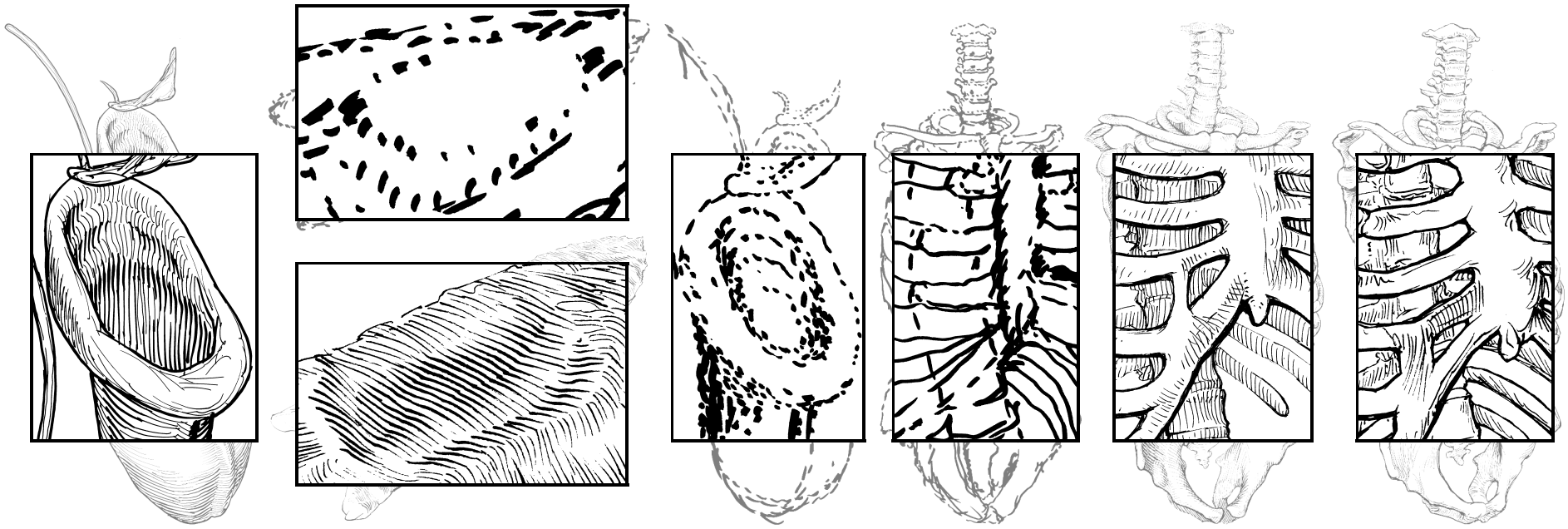

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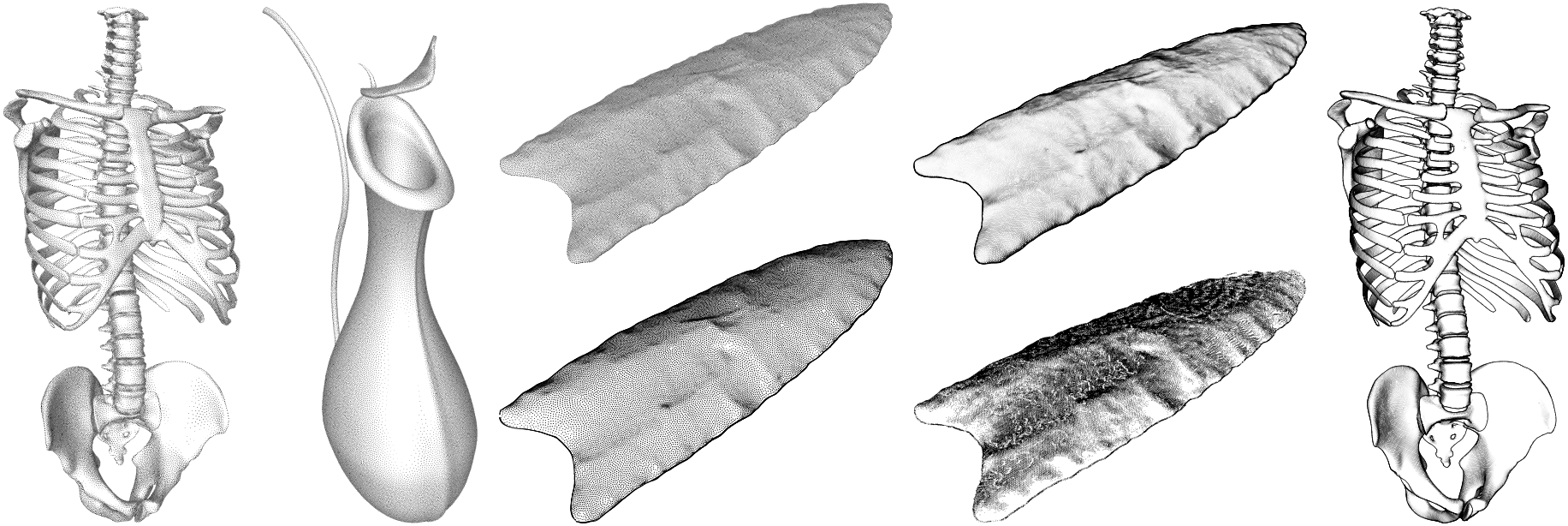

88% 79% 79%/58% 54%/42% 46%

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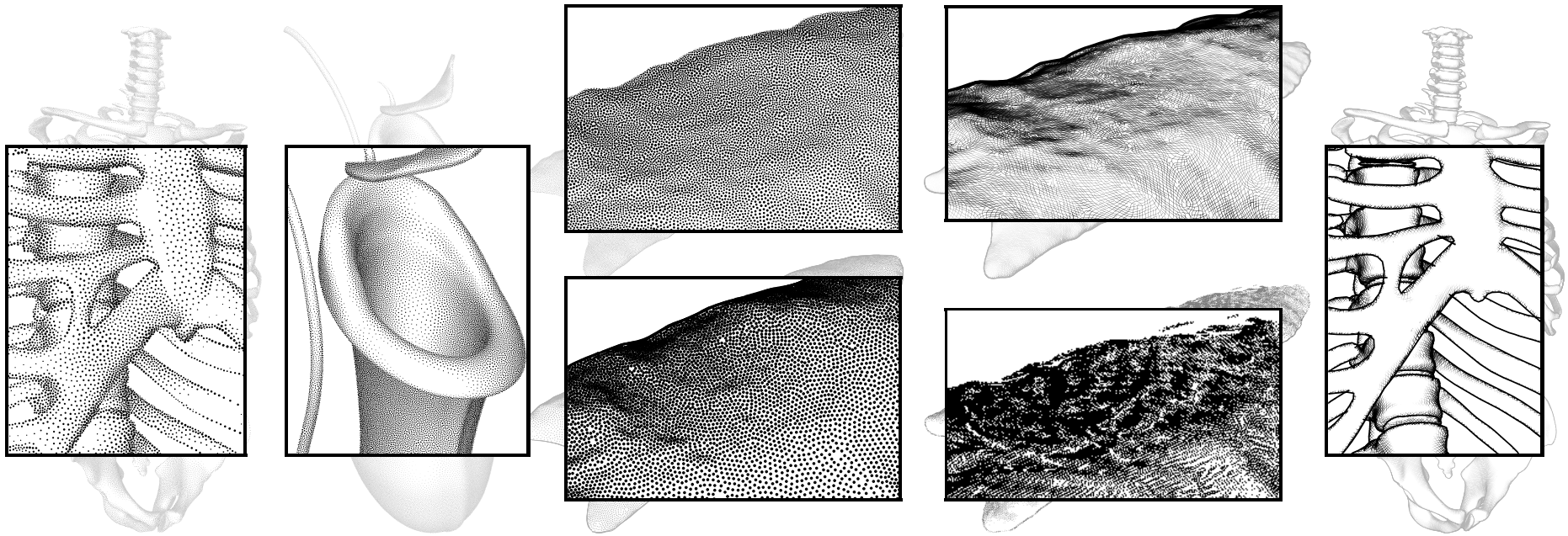

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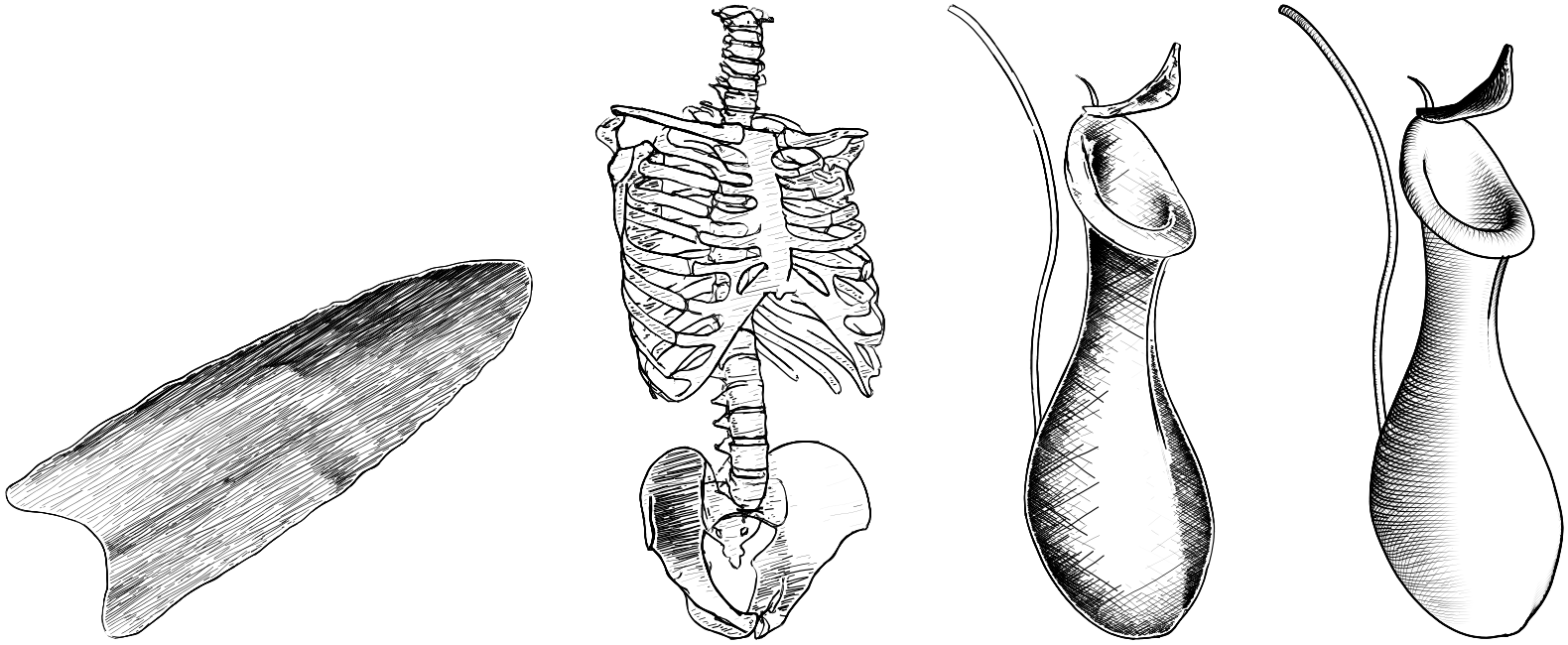
- some cg images frequently thought to be hand-drawn:



67% 63% 46% 29%

- randomness, longer and less dense lines, lower detail

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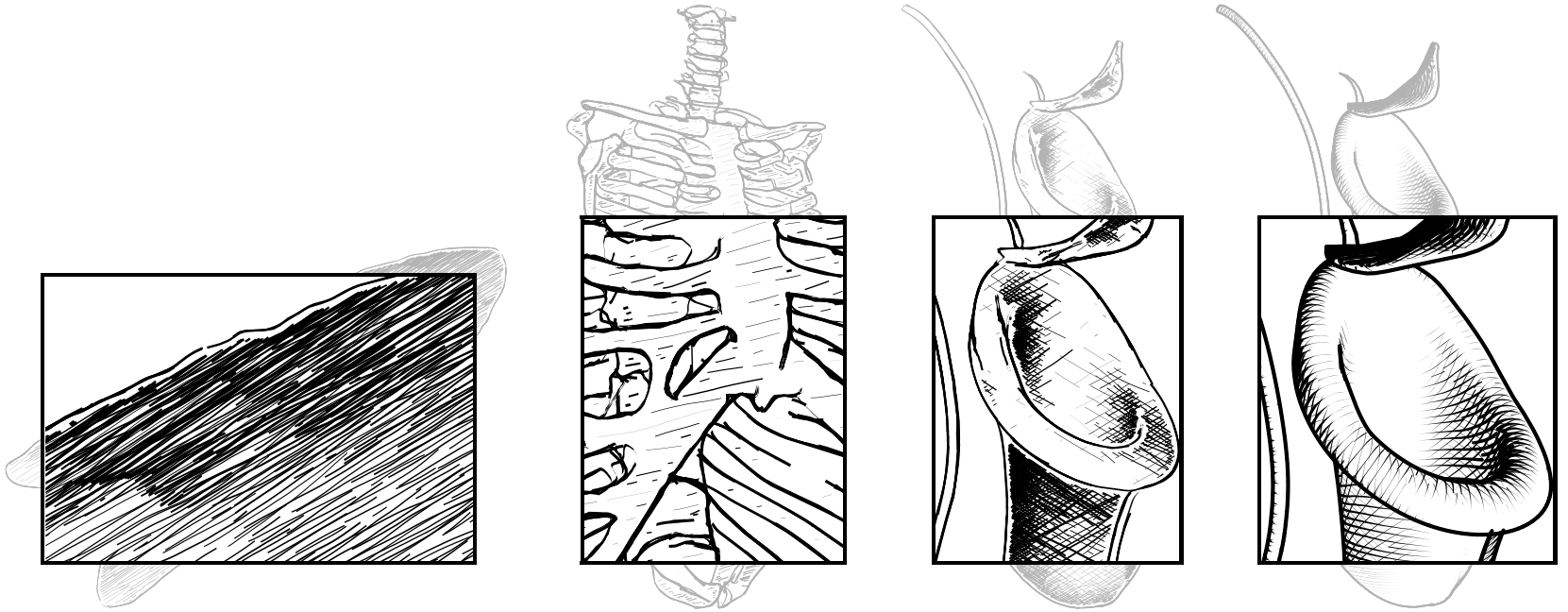

67% 63% 46% 29%

- randomness, longer and less dense lines, lower detail

Discussion

- NPR-Turing test not passed, CG images recognized as such (named standing out as hand-drawn by $\leq 29\%$)

- some almost always recognized as CG:
  detail, 3D shading, exactness

- depending on algorithm AND parameters

- one major exception:
  RenderBots hatching
  "sketchy", *"simplified"*,
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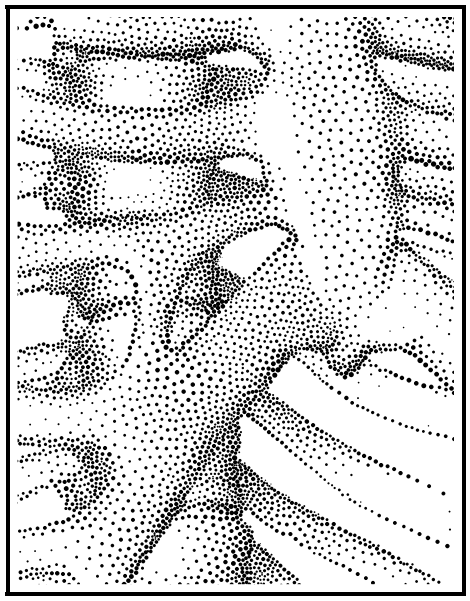

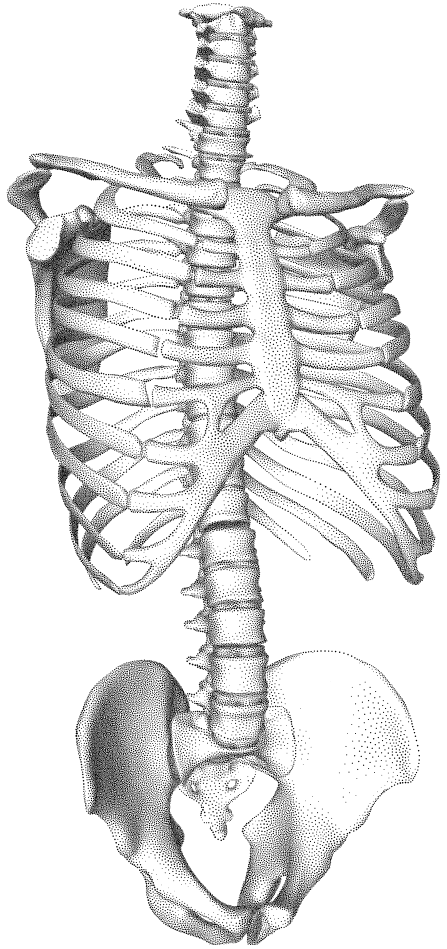

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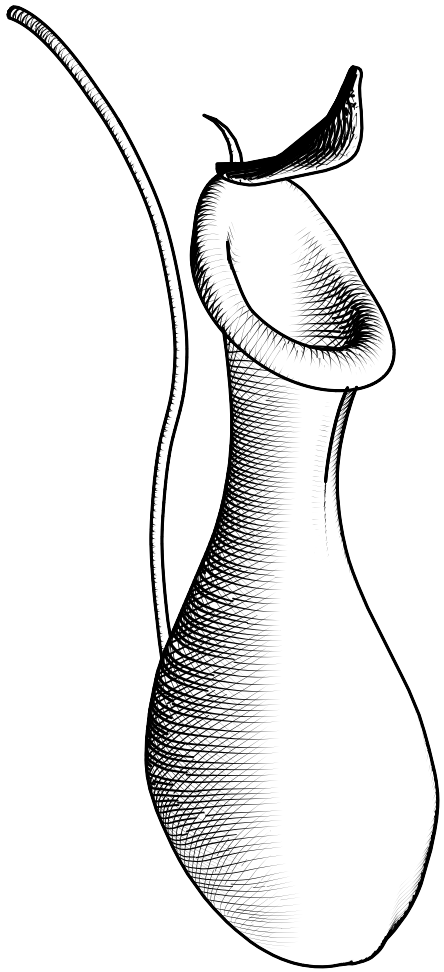

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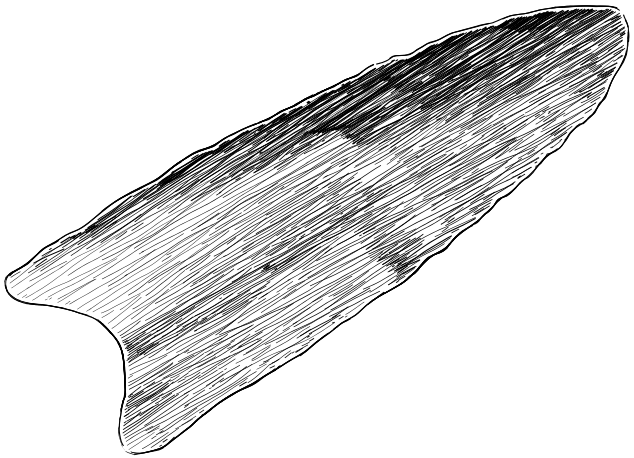
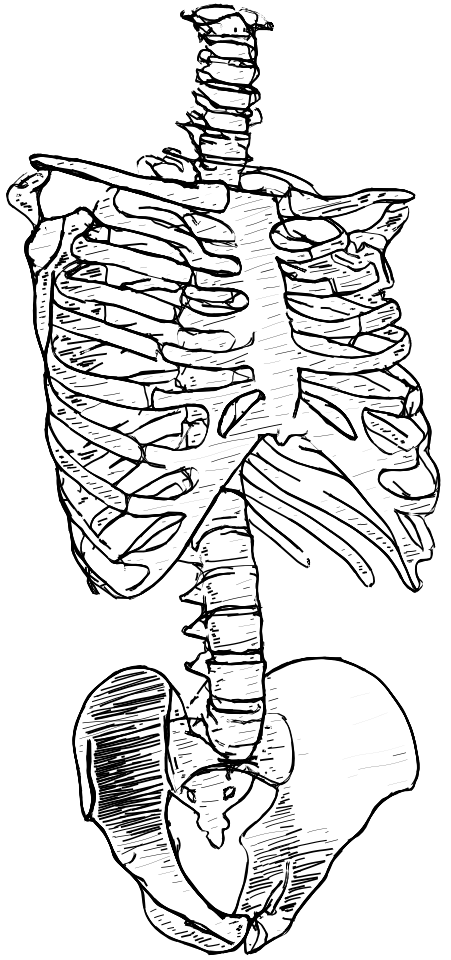
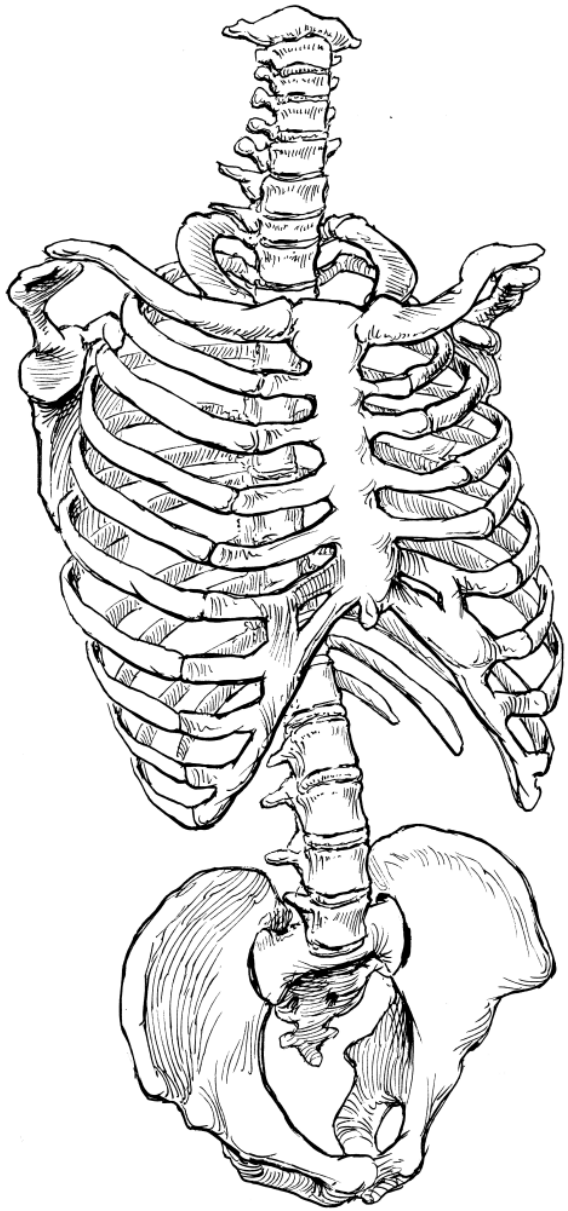
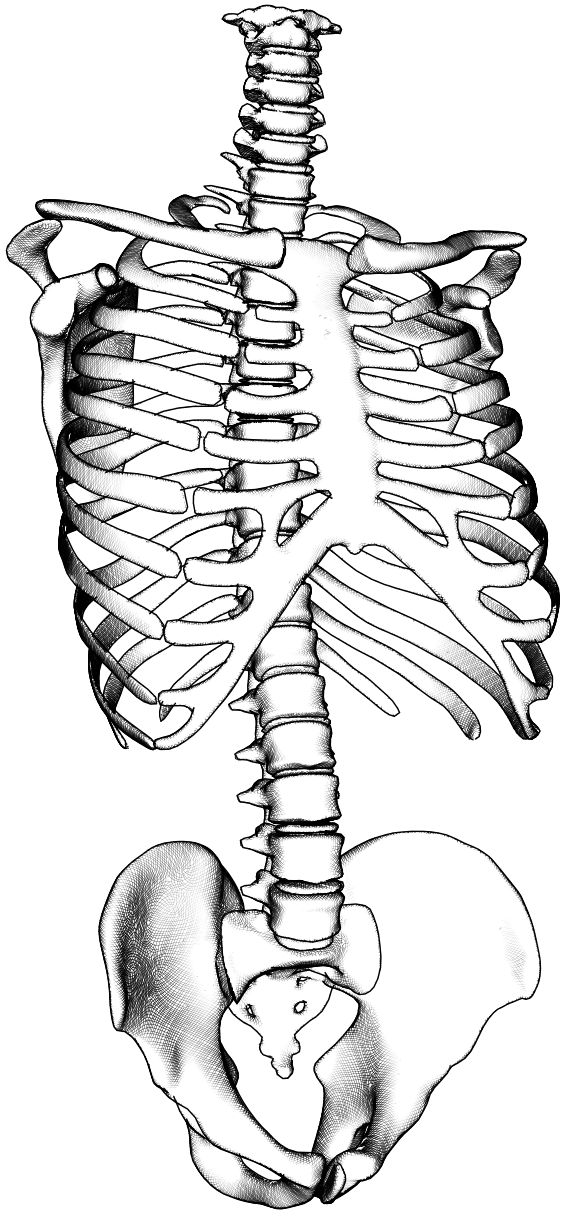


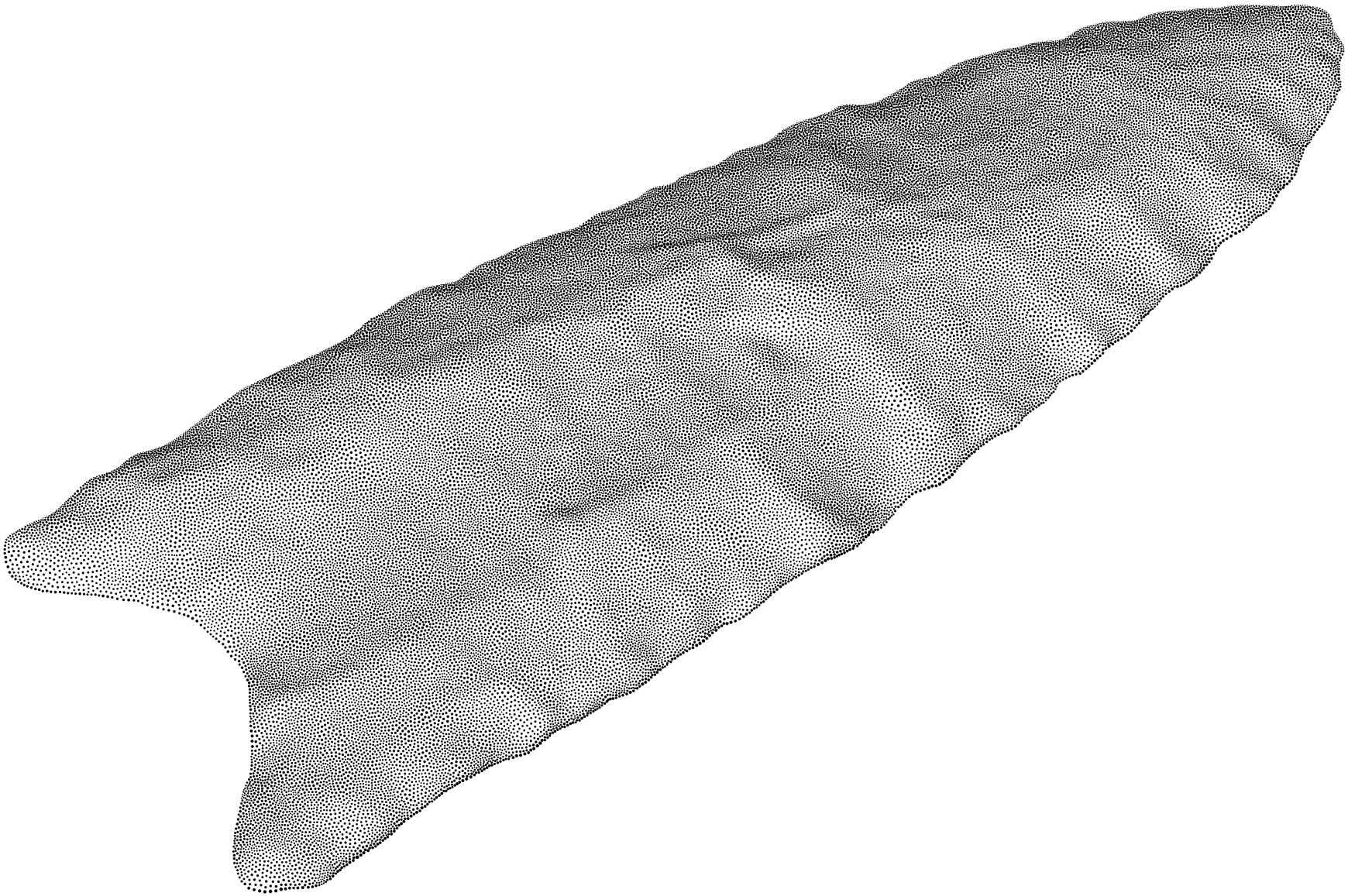


Impact for NPR Research: Know your goal & audience

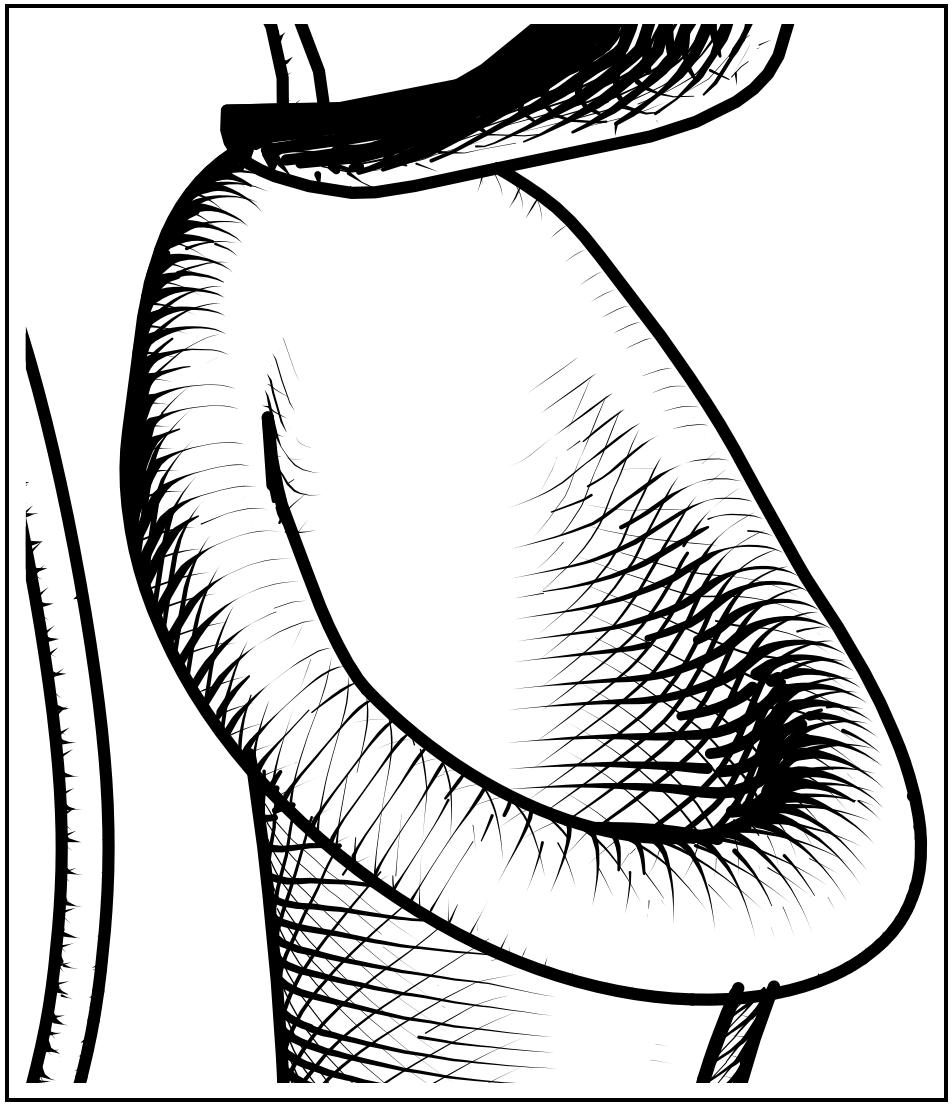




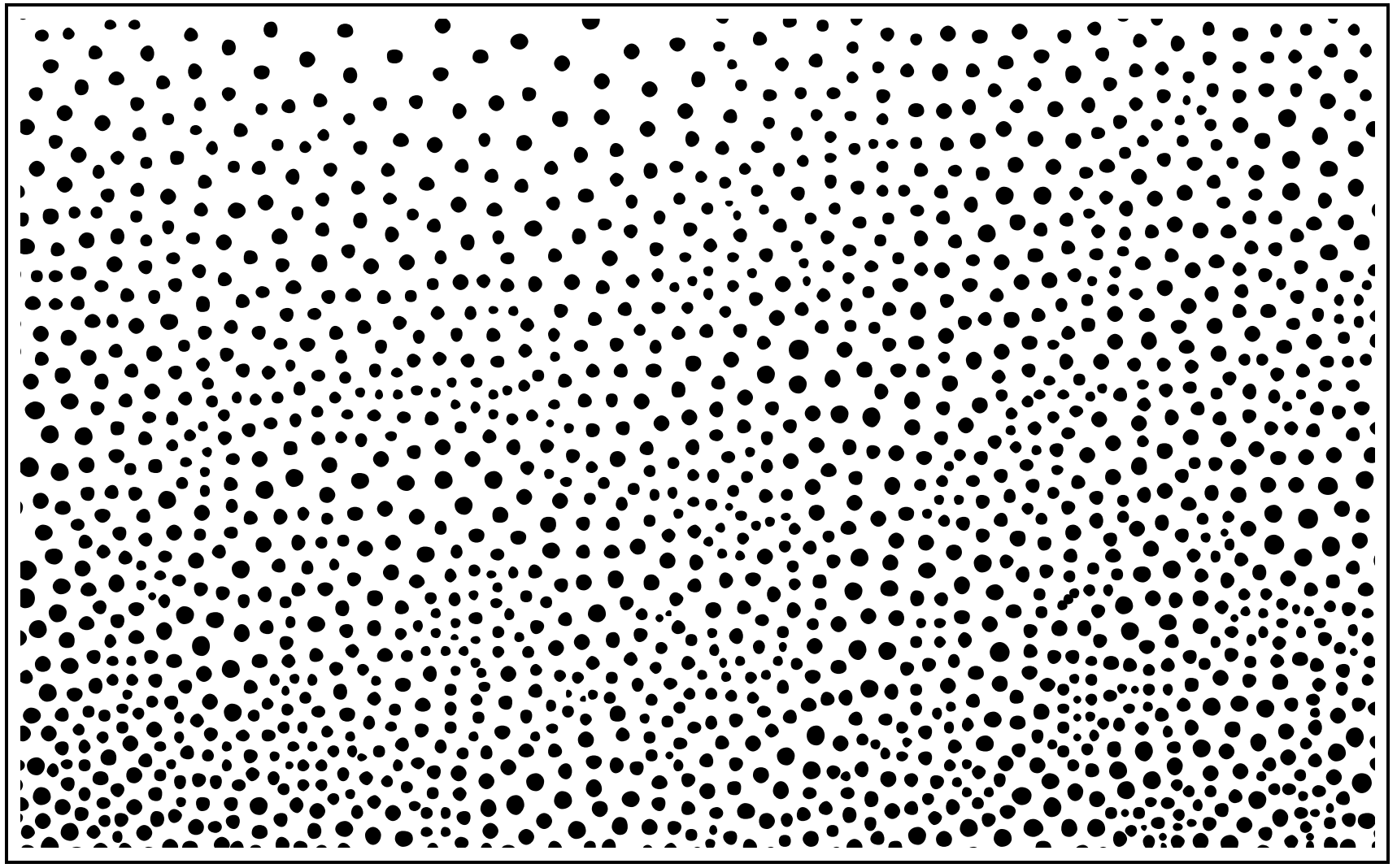
Impact for NPR Research: Portray materials



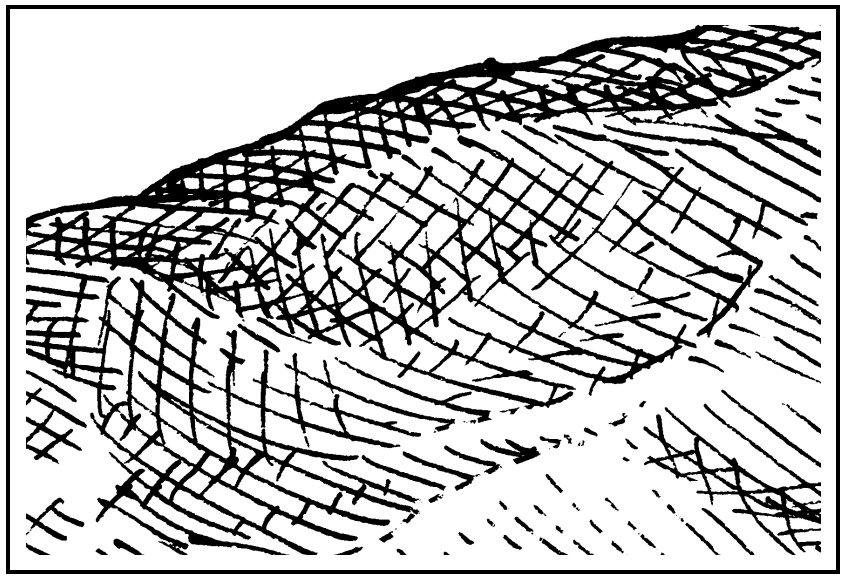
Impact for NPR Research: Work with models

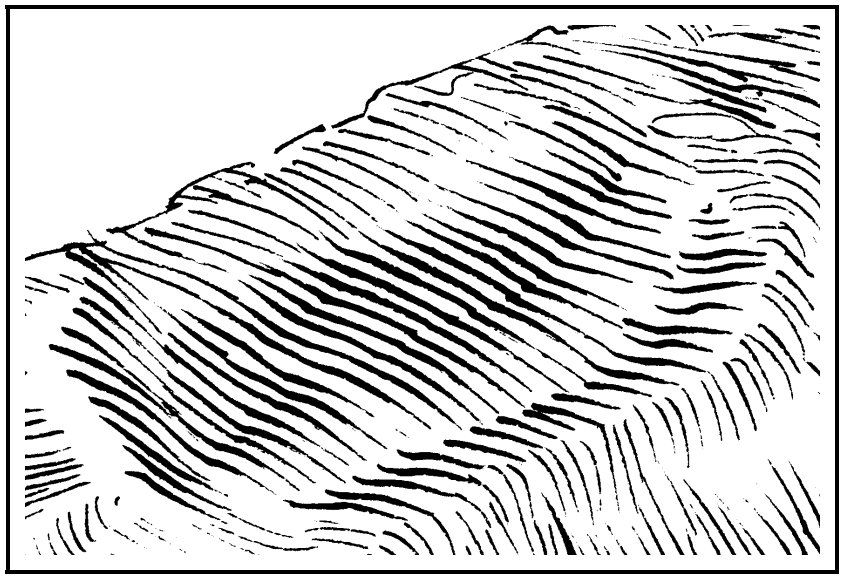


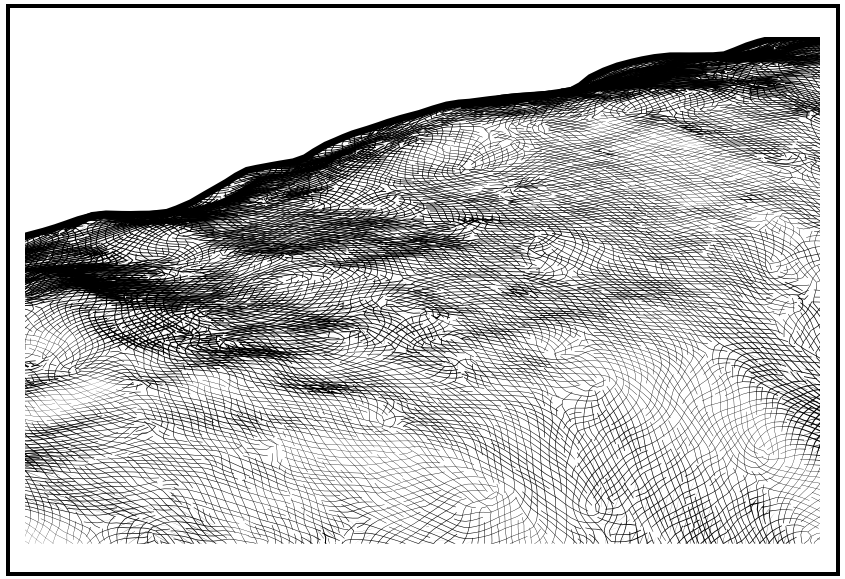
Impact for NPR Research: Avoid regularities

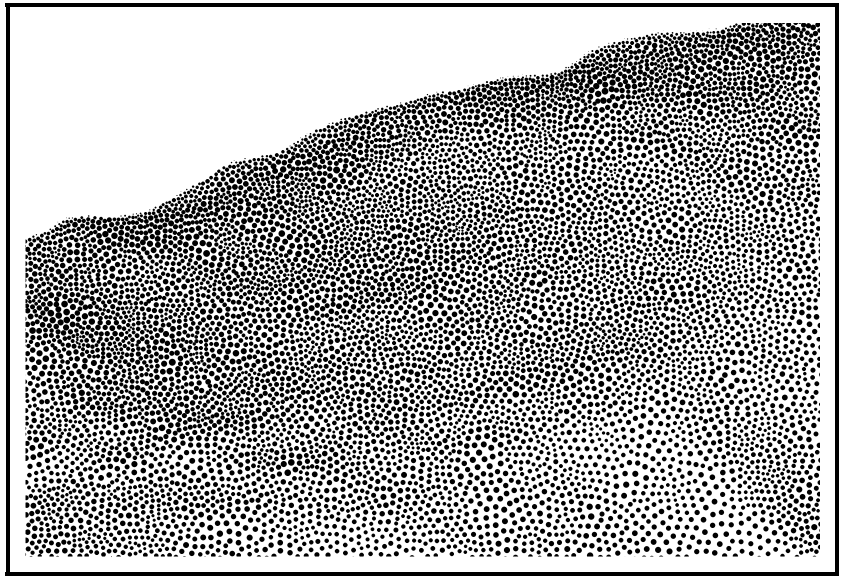


Impact for NPR Research: Pay attention to marks

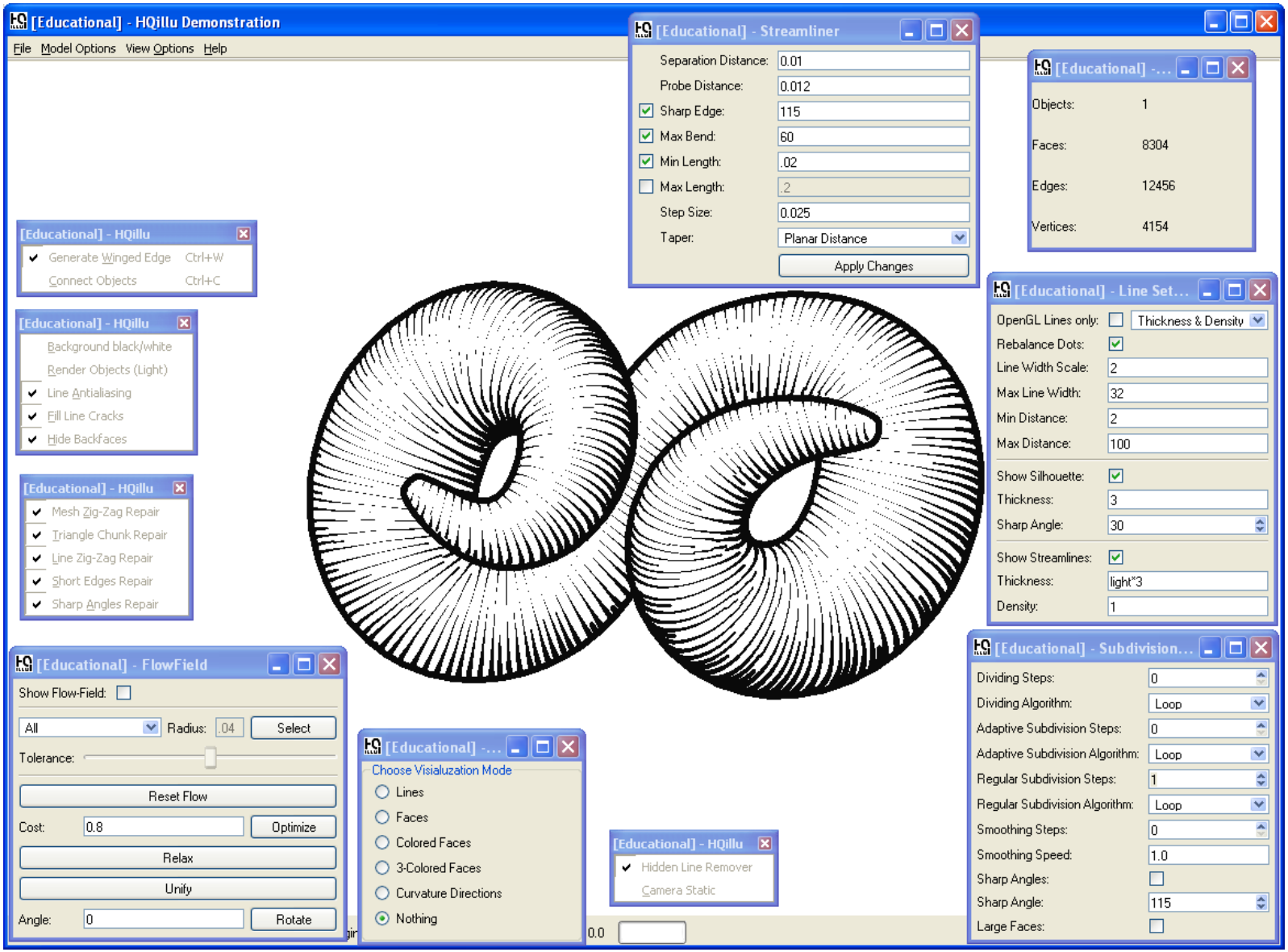








Impact for NPR Research: Pay attention to tools



Main Message:

We can **learn much about scientific illustration** by observing **how people look at illustrations** and asking them what they see. The **insights gained from evaluating NPR** can help to improve our non-photorealistic techniques.

Thanks for your attention!

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