 Modeling and Assembling Visual Devices to Compare Stem Cell Processes

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**KEYWORDS** Biological illustrations, biotechnological processes, educational tools, information design, information mapping, medical harmonizing, stem cells, stem cell research, symbol language, symbol semantic visualizing, visual systems for navigation

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**ABSTRACT** By designing with clarity and integrity, aesthetics and information can be effectively combined to inspire users to rapidly glean knowledge and understanding from complex subjects. By illuminating the functional truths between things, good design can empower others — of any age or origin — to discover solutions and yield the means to tenaciously resolve problems. These beliefs have sparked a shift in my practice within what I call “bedrock knowledge areas,” and the communication systems to convey and publish these. As an educator, my goals are continually set on discovering and stretching each stu-

**FIGURE 1:** As art director, information designer and illustrator, Julia Wargaski collaborated with two biologists, content and content flow creators, Katayoun Chamany and Lianna Schwartz-Orbach, to co-create the Sources of Stem Cells Radial and the twelve related detailed sheets for the Stem Cells Across the Curriculum (SCAC) grant, funded by New York State Stem Cell Science (NYSTEM) and The New School. To access the original designs for the Sources of Stem Cells Radial and twelve related detailed sheets (detailed sheets potentially also called Zoomgraphics), and for details about collaborators, funders, permissions for use, and to watch the video walkthrough accompanying these designs please go to the SCAC website.
Figure 2: At left: In my mind’s eye, initial visions of design solutions happen in 3D, in motion and with interactivity and are then transformed into 2D stills. The strongest initial influence for this sketch was after immersion in some content that was also in SCAC’s initial resources list. I proposed this mega cell visualization idea to the SCAC Team, on September 8 2010. Just the lower radial portion of this sketch was brought to fruition through collaborations with biologists Katayoun Chamany (PI) and Lianna Schwartz-Orbach which became the final design of the “Sources of Stem Cells” radial seen below.
dent's highest abilities: adaptability, visual and intellectual acuity, design adeptness, and tenacity. I strive to provide an environment where choice and experimentation, through visualization modeling, will be the catalyst for these qualities to arise and be fulfilled. As one individual under a multifaceted collaborative group grant, Stem Cells Across the Curriculum (SCAC), there emerged an excellent opportunity to immerse myself in such bedrock knowledge — biological content. The designer’s capability to dive deeply into ostensibly complex areas of science, and provide meaningful contribution through information design, is dependent on their capabilities in establishing hierarchies and taxonomies against the available resource and resultant modeling acumen. Developing effective educational tools, which will pass on key learning moments through the creation, integration, and balancing of these hierarchical systems, image assemblies, and typographical “shifts,” is the objective. It is often an all-consuming endeavor, involving time and meticulous care that well exceeds available funding, yet becomes an investment in its own right. The objective must be to create visualiza-

Figure 3: Blue highlighted areas illuminate main categories of conceptual and navigational integrations.
tions that achieve the highest possible level, based upon all known research, which reveals an empowering insight into the context of the knowledge with a commensurate capability to understand the specific. With these kinds of objectives and methods at hand, a designer can create the single element (the grammar) that combines, through a highly structured semantic, to create visual intelligence that is at once specific and contextual. This paper follows a case study where single visual elements throughout are taken through highly structured iterations for “Sources of Stem Cells” diagrams and related compositionally detailed information sheets.

**SOURCES OF STEM CELLS**

I have included the core illustrations, and the logic under which these are created. Design, being spatial, allows us to look at the completed model, the “Sources of Stem Cells” radial, and understand how all the components build into a complex, but easily accessible construct. In this comprehensive radial diagram the two main categories of “in vivo” and “in vitro” are centrally located (see Figure 3). Fueled by my inspiration from the first split of a cell, the concept of splitting is depicted as the categorical “split” at the center. As you move down through Human Development, in vivo, you reach the human body and above you see a dish labeled “HeLa 1951.” Moving up and around you encounter stem cell processes in vitro following along human growth from “Embryo” to “Fetus” to “Adult.” Moving out from the center, via concentric circles of expansion, are cell processes, genetic information, cell line, cell type, potency, biological references, as well as ethical, legal, and social references; these are further supported by overarching ethical issues. References for each process, which are divided into the two main categories, “Biological References” and “Ethical, Legal and Social References,” are seen in the outer rings. Each has a clickable circle representing “Readings/Other” or a clickable arrow representing “Videos” which takes you directly to that resource online. The work was primarily designed to be viewed digitally, through crisp and clear PDFs. Thus, the ability to zoom into the illustrations, and thereby move in and out of cells would be provided; this was then supplemented by typographical elements whereby selection would access relevant online resources. The twelve detailed sheets, which were then termed “ZoomGraphic,” would facilitate the unpacking of requisite detail. Most of the processes shown in the “Sources of Stem Cells” radial, and the radial itself, are not merely stand alone designs. Their efficacy is connected to, and understood more fully, when seen in connection with the team’s other materials. Of particu-
lar importance is the initial viewing of the "Sources of Stem Cells" video, a walkthrough available on the SCAC website. Similar to my blue highlighted version, this video walkthrough, which Katayoun Chamany and other team members have created, will also give details for how case studies map to the radial. The point is that varying media sources, used in conjunction with each other, build the greater picture of familiarization. The video is an excellent window into the composed visualizations — conversely, core portions of detailed sheets were integrated into portions of some animated PowerPoint presentations. Together, the visual tools leverage the curriculum.

EARLY STAGES, INFO GATHERING & PROCESS

Because the project spanned several years, this overview is necessarily cursory. The descriptions and visuals associated with the process embody only the broad strokes of conceptual design factors I developed in order to "solve" for the visualizations that emerged from the undertaking. The process of creating the taxonomy and hierarchies to render the bedrock knowledge can be deductively understood through the thirteen visualizations. As is generally the case with effective designs it appears self-evident after the visual language has been constructed and the visual devices are appropriately deployed within that language. Successful design teams (composed of designers and subject experts) must be ever mindful that the pre-visual endeavors for creating an effective matrix is often a major part of the entire effort. The SCAC grant from New York Stem Cell Science (NYSTEM) was awarded from July 2010 – July 2012 (the team was granted a one-year, no-cost extension), this was then supplemented by an award from the Innovations in Education fund from the New School. Numerous, and quite lengthy phases, were involved in obtaining relevant information from the subject-expert biologists, Katayoun Chamany and Lianna Schwartz-Orbach. Ultimately, this allowed the comprehensive build-out the proposed "Sources of Stem Cells" radial.

Choosing Scala as the typeface was one of the least difficult tasks. My initial tests revealed that it supported hierarchical efficacy, navigability, and readability throughout multiple layers of complexity. In short, it brought clarity to the challenge of multiple textual layers. Typographical design played a role as did type color. Elements seen in brown are related to in vivo processes and typographical elements seen in gray are related to in vitro processes. Design process was not influenced by adopting previously established systems and methods, but design choices were instead driven by facets of immersion in

FIGURE 7A: Structures for layered illustrative integrations are balanced mostly through simple systems of circles and squares. Each loosely occupying a unit of circle or square to create, when placed next to each other, a synergy through interstitial balance when seen as a whole. Where possible, representations were simplified to essential aspects. The goal was to remove unnecessary noise and still be able to integrate more and more visual elements while still maintaining a balanced tug on the eye.
biological content and design instinct with information design as educational tools as the guiding force. Sometimes, as designers, our ability to work in non-linear ways with overwhelming amounts of information, our capacity to become immersed in the content, and our drive to materialize solutions to visualizations of the big picture is not entirely understood and we assume others will be as comfortable and as excited as we are with the complexity and durability of proposed design solutions. Additionally, during this complex and long process, what I considered experimental test visuals and internal rough work in progress phases, and labeled as such, others would see as completed solutions so clarifying and restating work in progress phases and process was necessary. After years of effort involving information gathering, changes in content flow, numerous additional content integrations, internal testing and collaborative challenges, the core systems of the designs remained largely the same.

**DIMENSIONAL, FLAT & DIMENSIONAL/FLAT HYBRIDS**

Visual elements for illustrations in biological processes break down into loose categories with some obvious overlap. The intent behind creating dimensional, flat, and dimensional/flat hybrid representations of cells structures and processes was to allow for different assimilation speeds when navigating and zooming in on the designs. These different treatments are meant to foster entrance into the design at multiple entry points and the capacity for knowledge to be gleaned from just one micro zoom in or a wide view of all spokes and their interrelatedness across all categories with more ease. Colors were deliberately applied to push forward in less saturated combinations and frequently with lower levels of contrast. The intention was to create less noise and allow the user to have more visual bandwidth remaining for assimilation of typographical elements and relevant connections across different categories of information narratives.

**KNOWLEDGE BUILDING**

An exciting aspect of the "Sources of Stem Cells" radial and twelve related detailed sheets is that they are free and accessible to the public for non-commercial projects, particularly in education. As long as one abides by the "Permissions for Use" (see website), one could build on the designs for educational and non-commercial purposes. Someone could download the PDFs, open them up in Adobe Illustrator, select an illustration, and visualize a better cell. Researchers could use parts of the design or fill it with their own processes to help them present their own findings and, in turn, others could build on that work.
Even though the files for the radial and twelve detailed sheets were not initially organized for on-the-spot disaggregation purposes, anyone who is well-versed in Adobe Illustrator could access the original designs which will continue to live on the SCAC website in their original form. This kind of inclusion, meaningful sharing, and knowledge building, not just with small selected groups but with the entire world and for free, is inspiring to me — my long standing excitement and fascination with systems in nature and biology fuels inspiration for future endeavors.

**Figure 8A:** Dimensional Category for illustrative elements. See pages 8 - 9

**Figure 8B:** Flat Category for illustrative elements. See page 10

**Figure 8C:** Dimensional & Flat Category for illustrative elements. See page 11

**Figure 8D:** Set of Twelve Detailed Sheets: ZoomGraphics. [See pages 12 - 15.] Some selected sheets are enlarged out of sequence for expanded view of more complex samples.
MODELING AND ASSEMBLING VISUAL DEVICES
TO COMPARE STEM CELL PROCESSES
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DETAILED SHEETS: ZOOMGRAPhICS

**Human Development in vivo**

- **Fertilization**
  - Zygote day 0
  - Nuclear Fusion: Fusion of egg and sperm provides a complete human genome (two sets of nuclear DNA). Upon fertilization, calcium ions flood the egg cytoplasm and trigger fusion of egg and sperm nuclei.

- **Totipotent**
  - Blastomere day 3
  - 8 cells

- **Pluripotent & Multipotent**
  - Blastocyst day 5
  - 150 cells
  - Cell Differentiation: As cells migrate in response to external signals to the uterus, they specialize or differentiate. The cells on the outer layer of the blasocyst are referred to as the trophoblast and support placental development. The cells in the interior of the hollow ball, referred to as the inner cell mass (ICM), are referred to as the inner cell mass (ICM) and develop into the fetus. Each cell of the ICM has the potential to differentiate into any cell of the body.

- **Multipotent**
  - Gastrula day 14

**Further differentiation into four germ layers**
- Endoderm
- Mesoderm
- Ectoderm
- Germ cells

Each germ layer gives rise to a different subset of cell populations in the body, giving rise to 200 different cell types in the adult body.

**Figure 9A: Human Development**

**Nuclear Reprogramming. Human Development**

**Figure 9B: Nuclear Reprogramming/Human Development**

**Extranumerary Embryo**

**Figure 9C: Extranumerary Embryo**
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Figure 9D: PGD: Preimplantation Genetic Diagnosis

In Vitro Fertilization

Oocyte Procurement

PGD allows parents to screen their IVF embryos for genetic variants that increase risk of disease or influence physical/developmental development. PGD can be used to create “sister siblings” without these variants and can benefit cells such as siblings living with disease. PGD is done by removing a small piece of DNA from the embryo and using a technique that does not negatively impact embryos for treatment of diseases.

PGD is performed prior to implantation and provides a comprehensive analysis of the embryo’s genetic material.

Research Embryo

Stem Cells:

- Stem cells are used to create pluripotent human embryonic stem cell lines (hESCs). These cells are not only used for research but also hold promise for regenerative medicine.

- Stem cell research has the potential to revolutionize the treatment of diseases such as diabetes, Parkinson’s disease, and spinal cord injuries.

- Stem cells can be differentiated into various cell types, including neurons, muscle cells, and others, which can help in the study of disease mechanisms.

- Stem cells can be used to create patient-specific models for drug discovery and personalized medicine.

- Stem cell research is still in its early stages, and many challenges remain, including ethical concerns and the need for large-scale expansion and differentiation of stem cells.

Figure 9E: Research Embryo

Figure 9F: Parthenote
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EMBRYO . GENETICALLY MODIFIED EMBRYO . SCNT . Somatic Cell Nuclear Transfer

**OOCYTE PROCUREMENT & TISSUE BIOPSY**
For the purposes of stem cell research, hormones are injected to cause the maturation of multiple oocytes (eggs) in the body (in vivo), which are then surgically removed. This process poses a risk of ovarian hyperstimulation syndrome (OHSS). Symptoms range from mild to severe and in rare cases can result in death. Additionally, oocytes (not eggs or sperm) are procured via tissue biopsy to serve as the source of nuclear genetic material.

**NUCLEAR TRANSFER**
The nucleus of the human oocyte is physically removed and replaced with the nucleus of a human adult somatic cell. The cell now has two sets of the human genome containing the maternal and paternal imprints of the somatic cell donor.

**MITOTIC ACTIVATION**
Clones are exposed to agents that stimulate the calcium gradient waves that accompany sperm entry during fertilization. The electrical gradient triggers mitosis. The SCNT clone has two sets of DNA, representing both maternal and paternal imprints of the nuclear DNA donor.

**SCNT CLONES**
The adult somatic nuclear DNA is reprogrammed by the cytoplasmic factors of the oocyte. These factors physically alter chromosomes via chemical modification. The specific location of these modifications allows genes involved in pluripotency to be activated. This reprogramming returns the genome to an "embryonic" state.

**ANT CLONES**
In 2005, the U.S. President's Council on Bioethics issued a statement and recommendations regarding the use of cloned embryos for therapeutic purposes. These recommendations have been widely adopted by scientists and federal agencies. The results of these studies indicate that cloned embryos do not develop normally. In 2005, Wilmut et al. cloned four embryos using SCNT, all of which died within 5-13 days of birth.

**BLASTOMERES**
- Day 3: 8 cells
- Day 5: ~150 cells

**Blastocyst Development**
In response to cell culture conditions, the cells of the SCNT clone begin to specialize or differentiate. The cells on the outer layer of the blastocyst are referred to as trophoblast and support placental development. The cells in the interior of the hollow ball are referred to as the inner cell mass (ICM) and could possibly develop into the fetus.

**Nuclear Transfer Stem Cells**
In 2012, Shohat-Maugops et al. created two patient specific (pluripotent) nuclear transfer embryonic stem cell lines (mESC) via SCNT. He used six embryonic (from one egg) and one fetal (rat) somatic donor cells. These cells are being warehoused and used in research and therapy.

**SCNT: Somatic Cell Nuclear Transfer**

![Figure 9G: SCNT: Somatic Cell Nuclear Transfer](image)

**Figure 9G:** SCNT: Somatic Cell Nuclear Transfer

**Figure 9H: Cybrid**

**Figure 9I: Fetal Tissue**
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ADULT. GENETICALLY REPROGRAMMED

Induced Pluripotent Stem Cells

in vitro

CELL CULTURE & DNA REPROGRAMMING

Inducing Pluripotency: In 2007, Yamanaka identified four proteins factors that induce differentiated cells to adopt stem cell behavior. These factors include OCT4, Sox2, Klf4, and cMYC, which reprogram the cells by changing chromosomal architecture. The regulation of the DNA in some regions results in activation of “stemness” genes while the repression of other regions results in inhibition of differentiation-associated genes. More recently, epigenetic factors, such as histone deacetylases, have been shown to activate the reprogramming of chromosomal state and the reactivation of genes associated with pluripotency.

Inducing Immortality: “Immortality factors” including telomere-released enzymes and viral components, enhance cellular reprogramming efficiency and stabilize chromosome ends. These factors were essential in the immortalization of HeLa, the first human cell line, established in 1951.

Delivering the Factors: Yamanaka used viruses to deliver the genes that code for OCT4, Sox2, Klf4, and cMYC. To reduce cancer risk associated with viruses and cMYC, clinical researchers directly expose cells to induction factors using chemicals, proteins, and RNA.

TESTING FOR PLURIPOTENCY

Cell Health: Cell death, incomplete reprogramming, and cell transfection (becoming cancerous) can occur. Scientists use microscopic analysis and a blue dye to evaluate cell viability and cellular architecture.

Pecorin for Pluripotency: As cells move into the “stemness” state, they lose specialized structure and adopt a rounded shape. The presence of processes resulting from these changes is detected using immunofluorescent microscopy.

Genomic Structure for Pluripotency and Immortality: Genomic structures that activate “stemness” genes and inhibit differentiation-associated genes are detected indirectly by the presence and location of epigenetic reprogramming factors on DNA. Gene expression changes are visualized using microscopy technology.

IPSCs: A patient’s cells are reprogrammed into “healing” cells that can transplantation back into the body after the tissue environment to repair degenerative tissue. Yamanaka and London challenged the main genetic landscape proposed by Washington in 1993 and were the first model for identifying diabetes and reprogramming cells. In 2015, Tallei’s team created human iPSCs (Fig. 9J) that were capable of reducing blood flow in mice. In 2013, Tallei’s team created human iPSCs (Fig. 9J) that were capable of reducing blood flow in mice. In 2013, Tallei’s team created human iPSCs (Fig. 9J) that were capable of reducing blood flow in mice. In 2013, Tallei’s team created human iPSCs (Fig. 9J) that were capable of reducing blood flow in mice.

Patient-drawn Stem Cell Therapy: Scientists use iPSCs to understand the basics of cell differentiation. When cells are partially differentiated to a specific cell type (a progenitor), they can be used for cell transplant therapy. In addition, researchers are exploring factors that direct differentiation to transplant stem cells to the body (in vivo), stopping induced pluripotency, which reduces the risk of cancer.

Figure 9J: Induced Pluripotent Stem Cells

Figure 9K: Blood Stem Cells

Figure 9L: Fat Stem Cells
BIOGRAFY

Julia Wargaski is an Assistant Professor of Communication Design at Parsons School of Design within The School of Art, Media and Technology. Her specialization is in information design and design processes. As Art Director, Information Designer, and Illustrator, Julia collaborated with Katayoun Chamany and Lianna Schwartz-Orbach, two biologists/content and content flow creators, to co-create the Sources of Stem Cells Radial Infographic and twelve related ZoomGraphics (Detailed Sheets). Julia transformed biotechnological processes associated with stem cell research into intuitive information design narratives that highlight the provenance, manipulation, and use of each stem cell type and its associated therapeutic and scientific potential — information design as educational tools. She contributed Art Direction, Design and Co-development of educational materials for Princeton Nonviolent Communication (NVC) and Application, Information and Visual design for the Ripple, Explore and Map views for the Shape of Change online archive in collaboration with Director Melanie Crean. She was Co-author, Art Director, and Information Designer for development of the “Trees of Trade: Biodiversity and Extinction” educational game interface visualizations and transitions showing progression of information design narratives and how to ‘play’ the data, based off of Katharina Seifert’s “Effects of Trade: Endangered Species of the Atlantic Rainforest,” and in collaboration with Katharina Seifert, Preethi Chethan and Mike Edwards — in conjunction with the Data-play/Parsons PETLab. In addition to teaching multiple levels of information and undertaking research projects, Ms Wargaski pursues commercial programs and multiple practical applications, including Information Design & User Experience Design hybrid investigations — UX/UI. Ms Wargaski holds a BFA in Communication Design from Parsons School of Design and was educated as a User Experience Designer through General Assembly’s NYC User Experience Design Immersive.