HEALTHY, HISTORIC BUILDINGS

Preserving Historic Places Conference

Indiana Landmarks
Fort Wayne, Indiana

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Is a historic building a healthy building?
What do we mean by healthy?

ESKENAZI
SCHOOL OF ART, ARCHITECTURE + DESIGN
Indiana University Bloomington

IMAGE: View across living room and dining room with kitchen doorway visible in the distance (Orthel, 2022).

This presentation is

...telling a story about a **house**

...to explain a **model for the questions we should ask** as we consider history, heritage, and health.

This is a story about using historic places, not restoring historic spaces.

Our understanding and use of history and heritage is driven by individual perceptions of what has happened and the value of those events to the present day. Interior spaces are often integral to heritage (as markers of understanding and identity; Hollis 2014).

Systematically evaluating heritage requires us to consider the myriad, obscured ways heritage intersects with social, economic, ecological, and other structures. Heritage professionals, designers, and everyday individuals must understand these systematic interactions to be preprepared for the decisions they make about how to use, alter, and value historic spaces. Existing preservation guidelines are insufficient to match our responsibilities of care and evolving heritage.

IMAGE: View across living room and dining room with kitchen doorway visible in the distance (Orthel, 2022).

WHAT IS HERITAGE?

Heritage is differentiated from history by use. **Heritage encompasses the ways we activate and use history and perceptions of the past to advance our identities and objectives, social connections, and political goals in contemporary society.**

Histories are often aggressively cleaned of disharmonious elements and presented as complete, idealized views of past life. Such a historical approach represents one particular view of what is real, authentic, historical, and knowable (e.g., Anderson 2015). In contrast, the reality of history—and particularly the reality of historic interiors—is a messy complexity of incomplete information, heritage actions and values, and material culture (Cunningham 2014; Beecher 1998; Vaux & Wang 2016; Orthel 2020).

The historian's process recognizes changing meaning in every-day relationships (Danto 1985/1964). Even the best attempts at interpretative neutrality contain the values of the interpreter (Gable, Handler, & Lawson 1992). As a result, history is a result of heritage production, even though history is often presented as authoritative and objective, even when it is not.

IMAGE: Photograph of "boys and girls conducting physics experiments at the Carlisle Indian School in Pennsylvania," shown wearing formal uniforms and haircuts while taking measurements on apparatus (US Department of the Interior, 1915, public domain).

WHAT IS PUBLIC HEALTH?

If we accept that connections to the past are important for human existence, **what are the connections between individuals' knowledge of history, assertions of heritage, conservation efforts, and measures of public health?**

Public health focuses on systems influencing broad societal health:

- **Hosts,**
- **Environments,**
- **Agents, and**
- **Vectors.**

This includes issues such as physical activity, injury prevention, air quality, public policies, and cross-cutting issues (e.g., economics, crime, environmental justice, disability access, and mental health) (Dannenberg et al., 2003).

Public health issues group into three categories:

Cognitive health and well-being

Physiological health

Social concerns

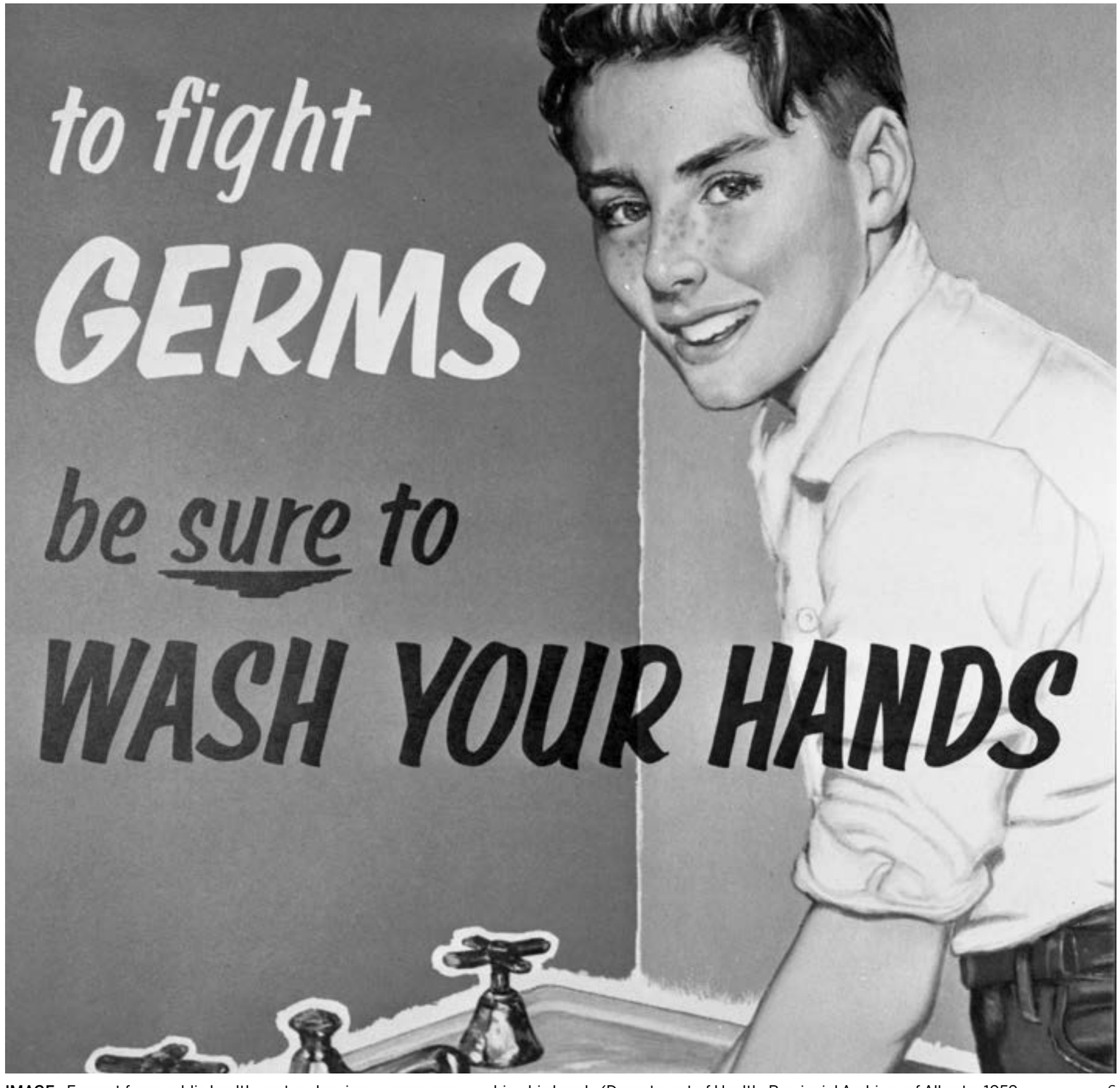


IMAGE: Excerpt from public health poster showing a young man washing his hands (Department of Health, Provincial Archive sof Alberta, 1959, Wikimedia Commons).

PUBLIC HEALTH and HERITAGE

The vast majority of the literature fits into two types:

- Discussion of history-heritage and health topics without identifying connections between them, and
- Evidence suggesting potential connections of history-heritage-health literature.

Grüning, Strünck, and Gilmore (2008) discussed difficult German public health campaigns to reduce tobacco use because of public wariness of Nazi-era campaigns.

Appler (2015) argued for improved access to affordable housing in historic districts as an economic and revitalization issue but did not note the documented health benefits such locations may have.

Kearney and Bradley (2015) discussed changes to heritage foodways, physical activity, and social interactions among immigrants, but did not connect that these changes will also affect the individual's health.

IMAGE: A nurse draws blood from a woman's arm. A poster about veneral disease is visible in the background. Oak Ridge, TN, 1947. (US Department of Energy, Wikimedia Commons).

PUBLIC HEALTH and HERITAGE

Yan (2015) noted public health goals could be used to enforce authorized heritage discourse.

Simms (2005) identified preservatives on museum artifacts as health risks during NAGPRA repatriation (see also Rossol 1998; Byrne 1979).

Baines (2015 and 2018) explored how traditional knowledge informed health care practices in a Mayan village through social roles, agriculture, and ecological issues (see also Riordan and Schofield 2015).

Hanibuchi et al. (2012) determined the age of a community is a better determinant of social capital than urban form or walkability scores.

Ander et al. (2013) reported a heritage-in-the-hospital outreach program (e.g., museum objects) resulted in patients' self-reporting improved wellbeing.

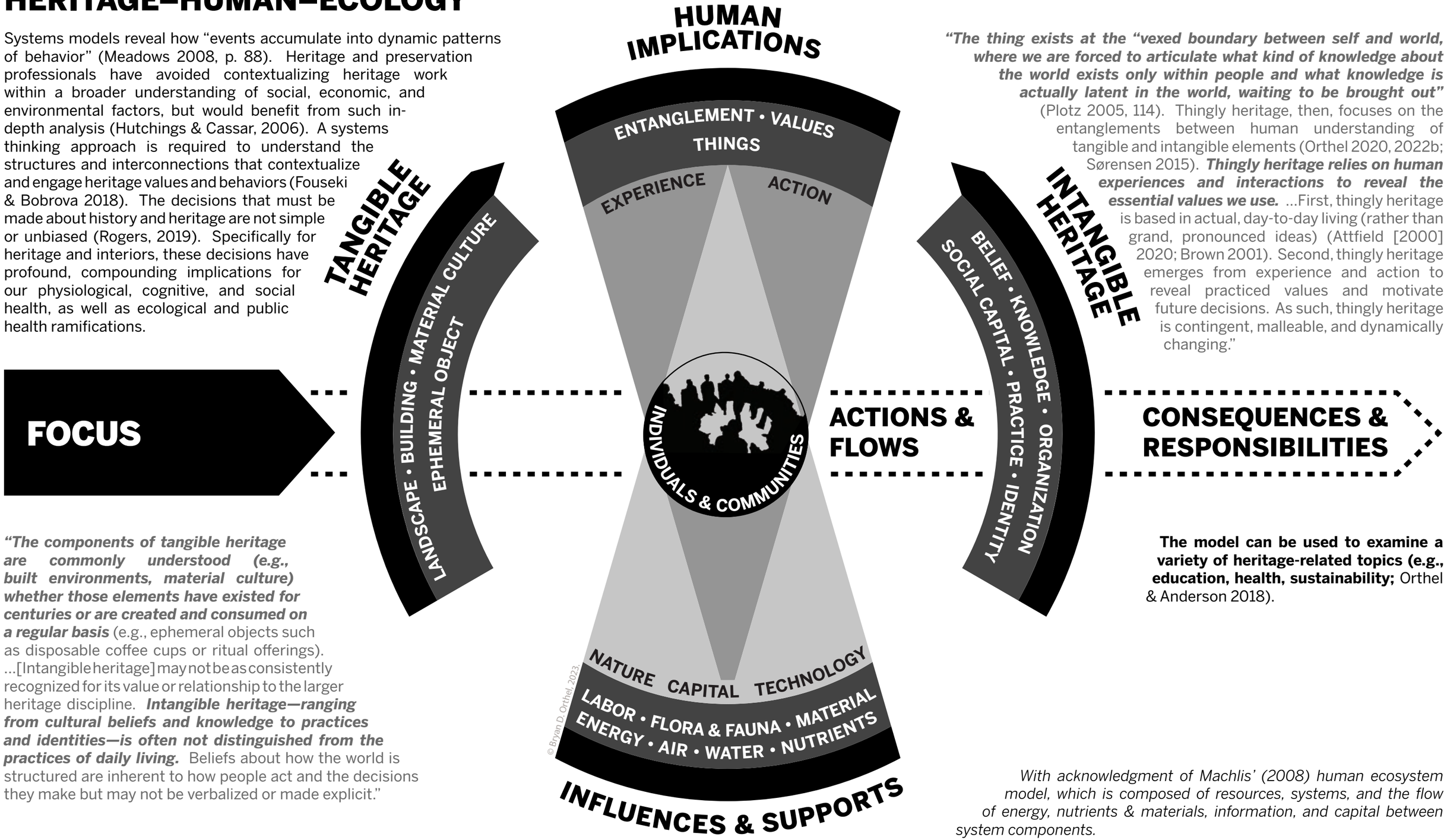
Power & Smyth (2016) reported volunteers who sought experiences supporting local heritage generally showed higher levels of social wellbeing. **Hallett, Chandler, & Lalonde (2007)** demonstrated use and knowledge of Indigeneous language reduced teen suicide.

(For more on the benefits to individual wellbeing from engagement with heritage objects, places, practices, and knowledge, see Bowden, Woolrych, & Kennedy 2025; Luck & Sayer 2024; Schofield 2024; Sektani et al. 2023; Sofaer et al. 2021; Pennington et al. 2019; Reilly, Nolan, & Monckton 2018; National Trust 2018; Power & Smyth 2016, Neal 2015; Ander et al., 2013; Bach-Faig et al. 2011).

IMAGE: A drawing of a man in a suit sneezing over a buffet of food. The caption reads" Careless sneezing! Use a hankie.". (New Zealand Department of Health, c. 1950, Archives New Zealand).

HERITAGE–HUMAN–ECOLOGY

Systems models reveal how "events accumulate into dynamic patterns of behavior" (Meadows 2008, p. 88). Heritage and preservation professionals have avoided contextualizing heritage work within a broader understanding of social, economic, and environmental factors, but would benefit from such in-depth analysis (Hutchings & Cassar, 2006). A systems thinking approach is required to understand the structures and interconnections that contextualize and engage heritage values and behaviors (Fouseki & Bobrova 2018). The decisions that must be made about history and heritage are not simple or unbiased (Rogers, 2019). Specifically for heritage and interiors, these decisions have profound, compounding implications for our physiological, cognitive, and social health, as well as ecological and public health ramifications.



"The thing exists at the "vexed boundary between self and world, where we are forced to articulate what kind of knowledge about the world exists only within people and what knowledge is actually latent in the world, waiting to be brought out" (Plotz 2005, 114). Thingly heritage, then, focuses on the entanglements between human understanding of tangible and intangible elements (Orthel 2020, 2022b; Sørensen 2015). ***Thingly heritage relies on human experiences and interactions to reveal the essential values we use.*** ...First, thingly heritage is based in actual, day-to-day living (rather than grand, pronounced ideas) (Attfield [2000] 2020; Brown 2001). Second, thingly heritage emerges from experience and action to reveal practiced values and motivate future decisions. As such, thingly heritage is contingent, malleable, and dynamically changing."

"The components of tangible heritage are commonly understood (e.g., built environments, material culture) whether those elements have existed for centuries or are created and consumed on a regular basis (e.g., ephemeral objects such as disposable coffee cups or ritual offerings). ...[Intangible heritage] may not be as consistently recognized for its value or relationship to the larger heritage discipline. ***Intangible heritage—ranging from cultural beliefs and knowledge to practices and identities—is often not distinguished from the practices of daily living.*** Beliefs about how the world is structured are inherent to how people act and the decisions they make but may not be verbalized or made explicit."

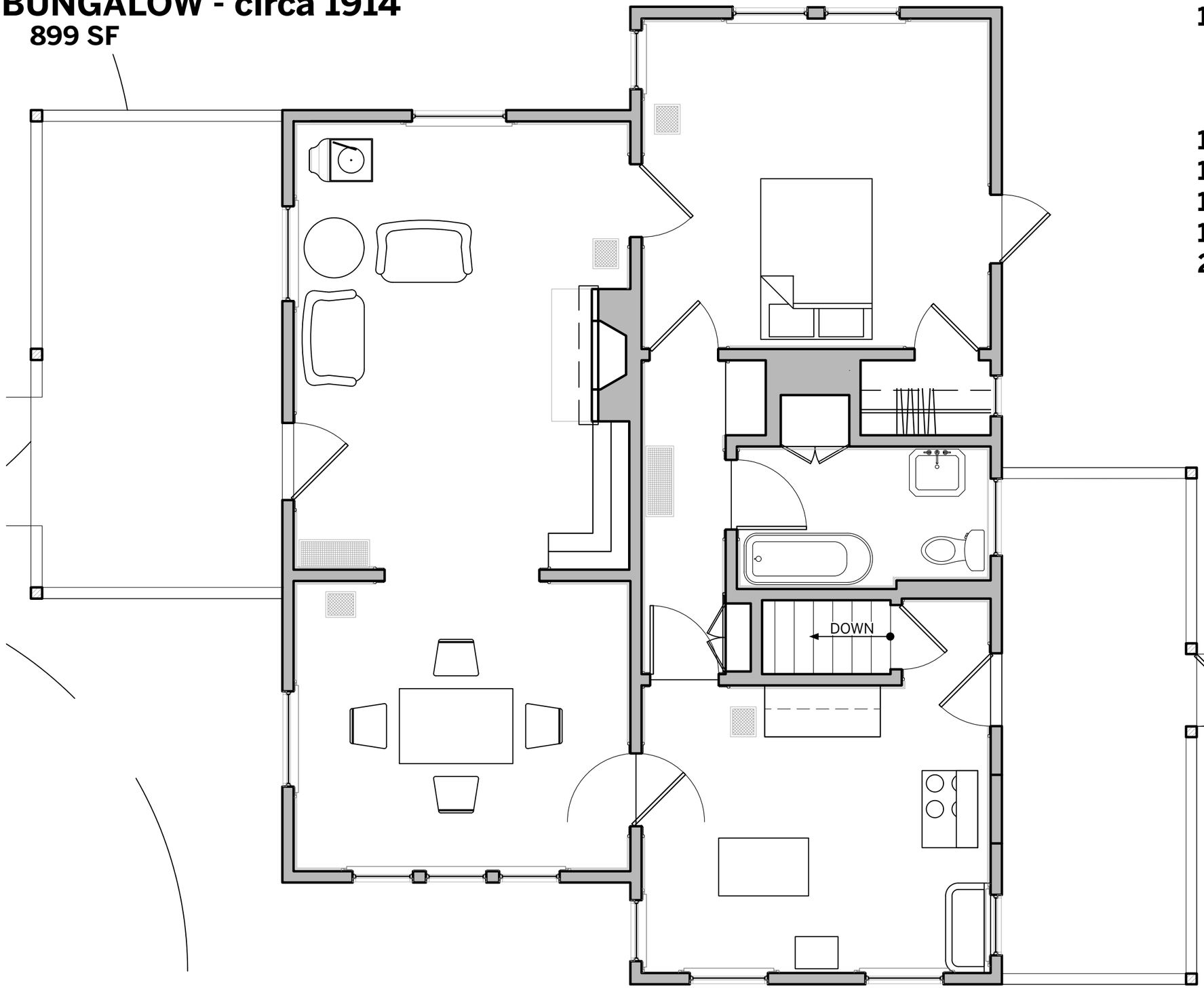
The model can be used to examine a variety of heritage-related topics (e.g., education, health, sustainability; Orthel & Anderson 2018).

With acknowledgment of Machlis' (2008) human ecosystem model, which is composed of resources, systems, and the flow of energy, nutrients & materials, information, and capital between system components.

IMAGE: Heritage–Human–Ecology model comprised of influences & supports, tangible heritage, intangible heritage, human implications, individuals & communities, a focus of analysis, actions & flows between model components, and the resulting consequences & responsibilities (Orthel 2022c).

BUNGALOW - circa 1914

899 SF



1914	Empty lot purchased by Mutual Building & Loan Association; house constructed
1915	Owner 1 (farmer)
1922	Owner 2 (professor)
1927	Owner 3 (businessman)
1958	Owner 4 (professor)
2018	Owner 5 (professor)

IMAGE: Floor plan of the c. 1914 bungalow (living room, dining room, kitchen, hall, bathroom, and bedroom) with front and back porches (drawing by author).

BUNGALOW - circa 2018

1,320 SF

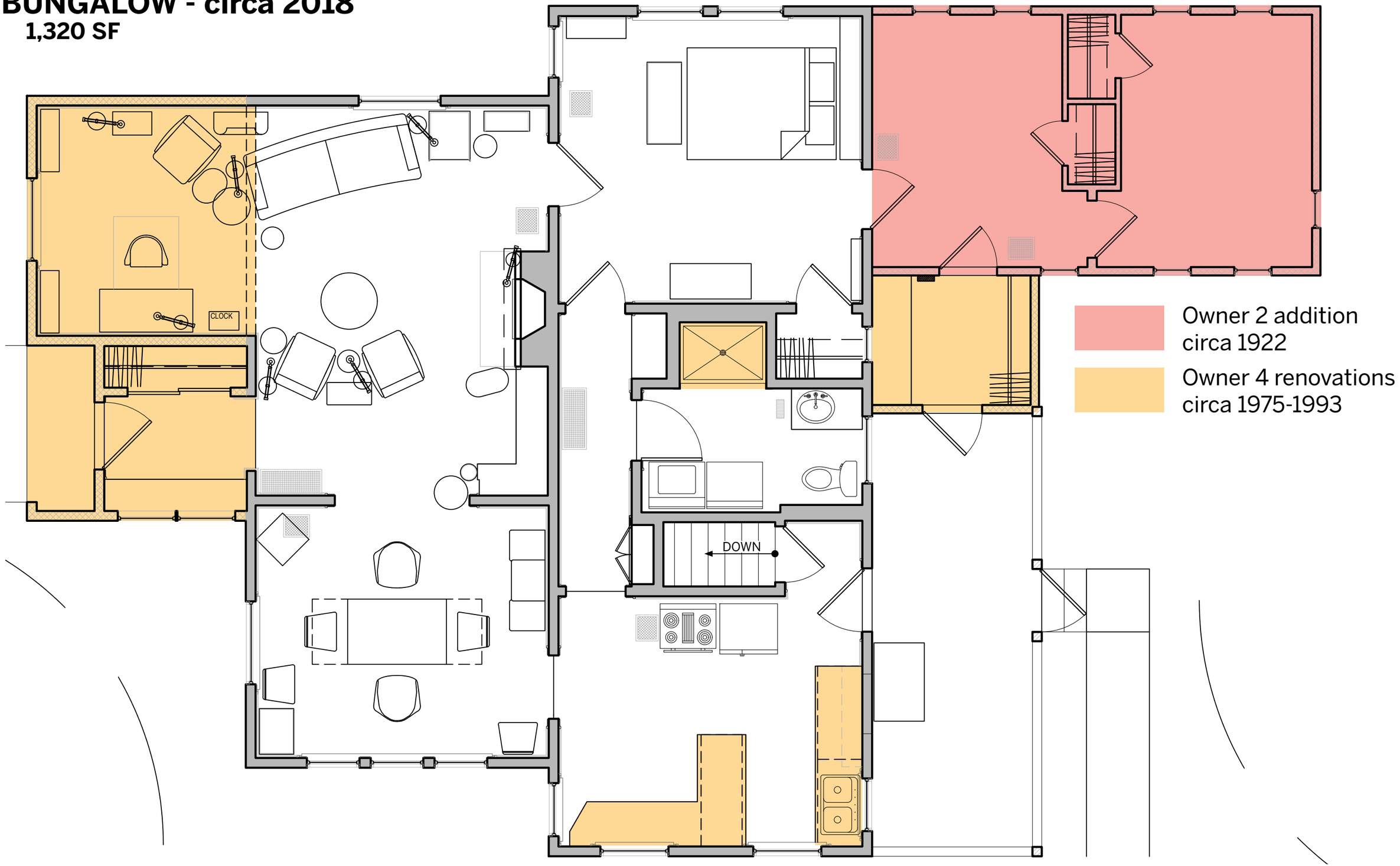


IMAGE: Floor plan of the c. 1914 bungalow in 2018, showing modifications to add two rear bedrooms, enclose the front porch, and renovate the kitchen and bathroom (drawing by author).

BUNGALOW - circa 2022

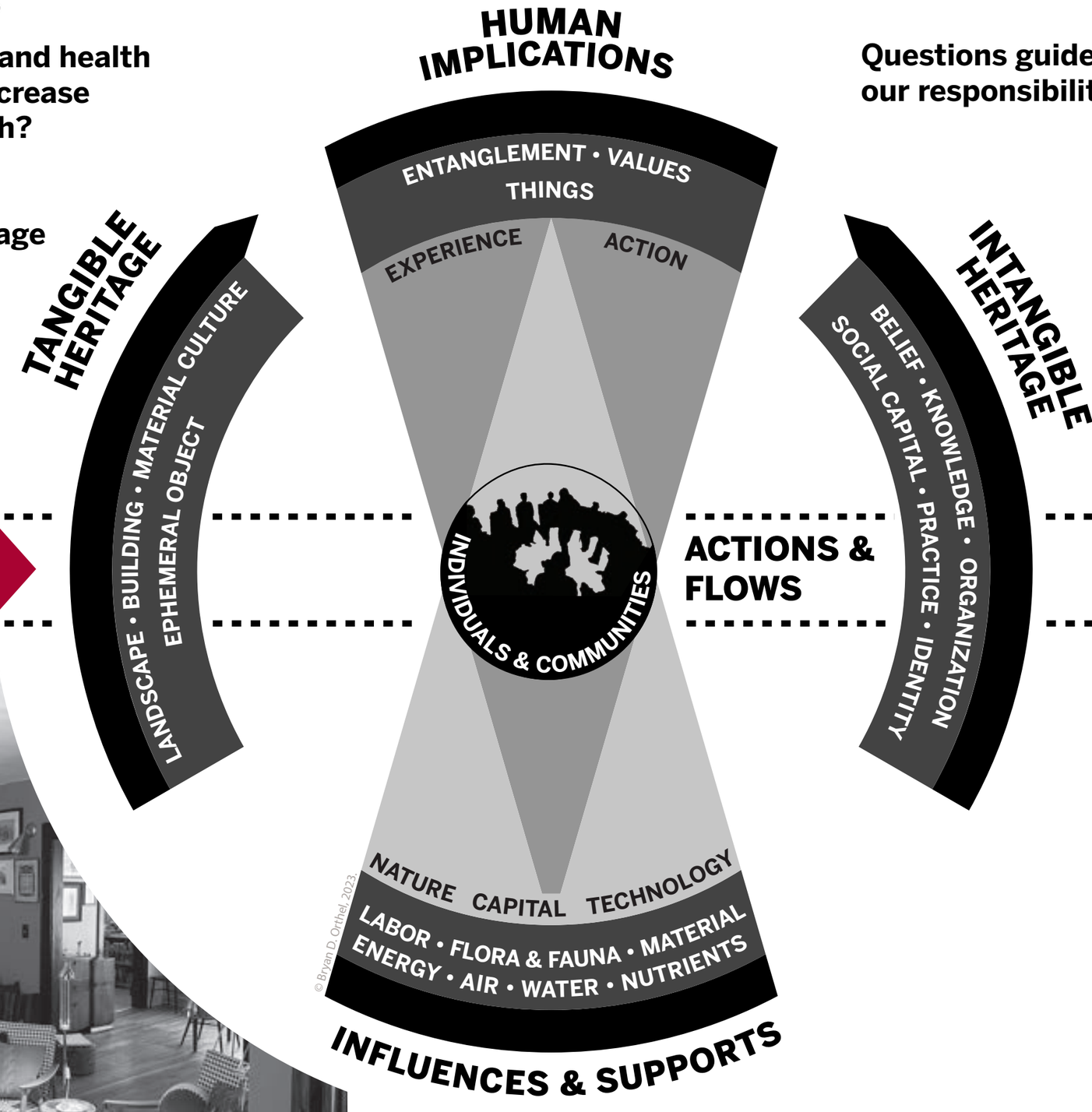
IMAGE: View across living room and dining room with kitchen doorway visible in the distance (Orthel, 2022).

CURRENT ANALYSIS

In what ways do heritage and health interact to increase or decrease measures of human health?

More specifically, what interior factors of heritage and health influence human health?

HEALTH + INTERIOR



ACTIONS & FLOWS

CONSEQUENCES & RESPONSIBILITIES

Questions guides future decisions about our responsibilities..

PROTECT

How does this interior PROTECT me?

HURT

How does this interior HURT me?

REFLECT

How does this interior REFLECT me?

ADAPT

How must I ADAPT to this interior?

IMAGE: View across living room and dining room with kitchen doorway visible in the distance (Orthel, 2022).

HEALTHY, HISTORIC BUILDING

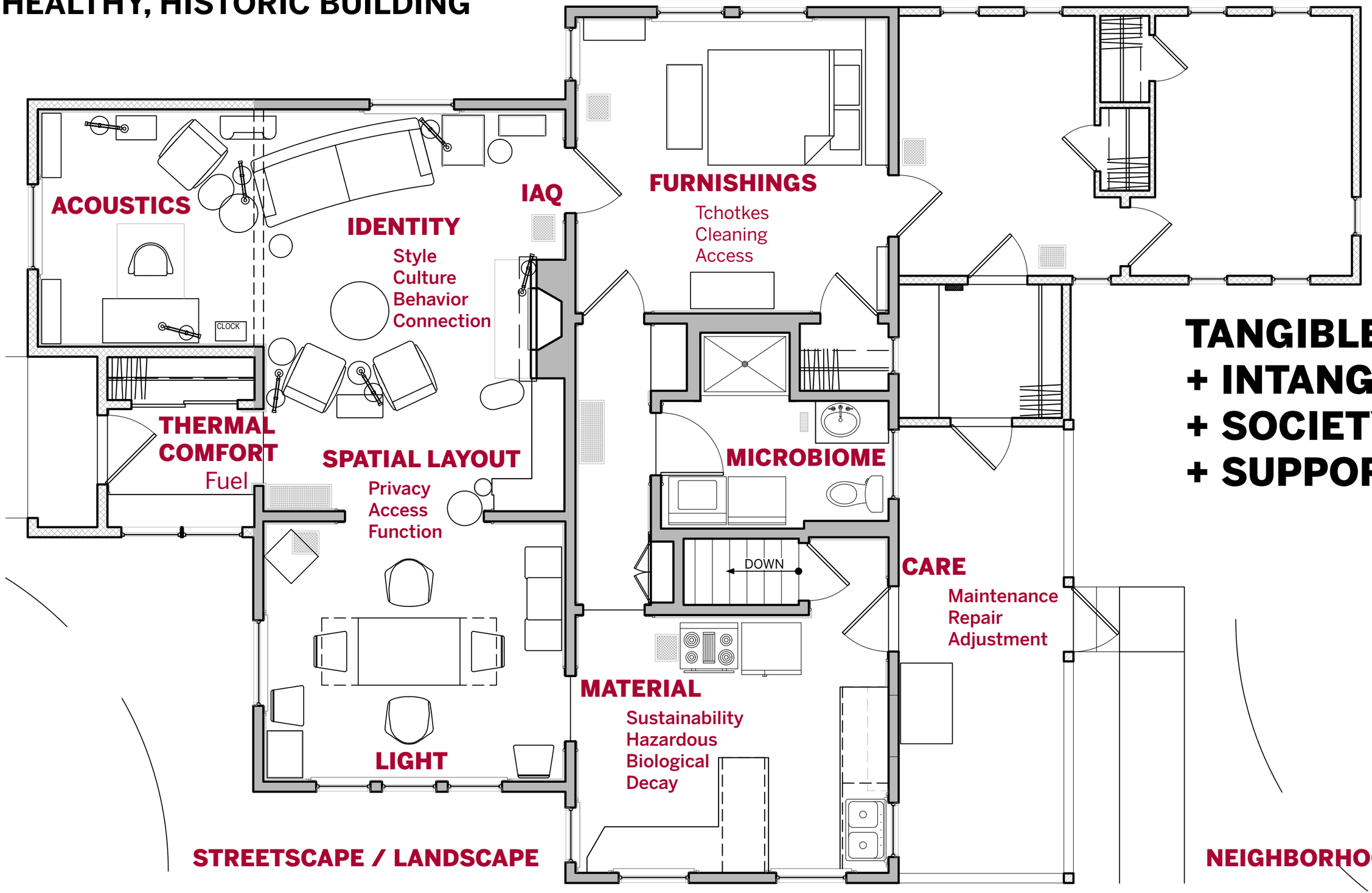


IMAGE: Floor plan of the c. 1914 bungalow in 2018, showing modifications to add two rear bedrooms, enclose the front porch, and renovate the kitchen and bathroom (drawing by author).

Identity defines how we—as individuals—recognize our own experiences and sense of self. Human identity may be defined through culture (including style), behavior, and connection with ideas and others. The stability of our identities and our ability to maintain identity are linked to human agency and ontological security.

Maintaining identity requires human agency and ontological security linked with heritage (Grenville, 2015 & 2007; DeSilvey & Naylor, 2011; Hodder, 2010; Smith, 2006).

Heritage supports individual identity and wellbeing (Smith, 2022; Pennington et al., 2019; Power & Smyth, 2016; Baird, 2014; Ander et al., 2013; Routledge et al., 2013; Twigger-Ross and Uzzell 1996).

Heritage often counteracts change as a way to protect identity (DeSilvey & Harrison, 2020).

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FOCUS	TANGIBLE HERITAGE	INFLUENCES & SUPPORTS	INTANGIBLE HERITAGE	HUMAN IMPLICATIONS	CONSEQUENCES & RESPONSIBILITIES
Health + Interior: Identity	*Landscape • Building • Material Culture • Ephemeral Object*	*Nature • Capital • Technology • Labor • Flora & Fauna • Material • Energy • Air • Water • Nutrients*	*Belief • Knowledge • Organization • Social Capital • Practice • Identity*	*Individuals & Communities • Entanglement • Values • Things • Experience • Action*	*Protection • Reflection • Harm • Adaptation*
Craftsman (-ish) bungalow Established neighborhood near university Associated with former faculty members (Really) one-bedroom house	Original materials Location in a mature neighborhood	Access to university Repair-ability Ready access to materials and building parts	Knowledge of former residents Knowledge of how the house has changed over time How house matters to neighbors	Craftsman aesthetic (stable and unadorned) Adaptable to eclecticism	P R House location, orientation, aesthetics, and experience reflects personal goals and characteristics P R Repair and maintenance are within the occupant's control. A H R Personal history and values may conflict with site specific history or materiality. A H R Changes to the house are scrutinized by neighbors. *Potential change is considered from multiple perspectives.*

Spatial layout may affect occupants' health through privacy, access, and function. Spatial layouts guide behavior through physical relationship of elements and access. The activities within a space may increase or mitigate risk. Control of individual privacy may affect perceived stress.

Spatial layout affects occupants' health through privacy, access, and function (e.g., acoustics, IAQ) (Valizadeh & Iranmanesh, 2022; Colenberg et al., 2021; Connellan et al., 2013).

Privacy control reduces stress.

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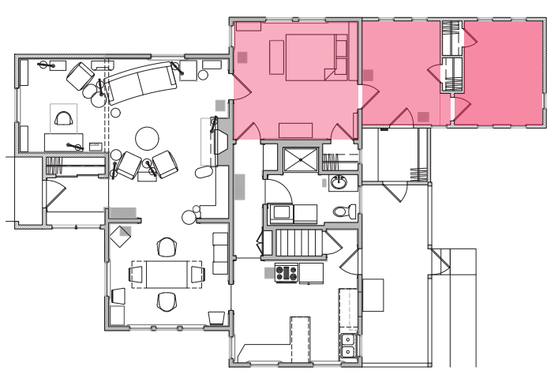
Moderately open floor plan Private-public separation Cooking open to dining (i.e., missing kitchen doors) Enfilade sleeping room sequence	Traditional separation of public-private Space and contemporary function may not match	Compact core reduces energy use Layout supports daylight and cross-ventilation	Living defined by space	Social gathering Excess of doors	A H P Public-private division is clear, but internal privacy is compromised. P R Compact plan limits required energy and resources. A H Limited space may place hazardous uses in incompatible spaces (e.g., cleaning supplies).



Furnishings in an interior affect the behavior and actions of occupants, whether self-selected or pre-existing. Furnishings may directly affect physiological health (e.g., ergonomics) and psychological health (e.g., perceived authority). Furnishings may be related to historic use, design, and occupant preference.

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Compact floor plan and door openings Tall ceiling Heirlooms, tchotchkes, and wall art Movement paths between spaces	Size of spaces controls placement and choice of furnishings Cabinetry sized to previous occupant	Cost of furnishing selection	Past use and previous owners inform current use of spaces. Display of heirlooms and other items associated with ancestors.	Aesthetic appropriateness / match between building and furnishings Décor and belongings Movement is through spaces (not through corridors) Finish selection	A P Re-inhabiting space based on past use reinforces continuity (e.g., place). P R Ontological security of identity reinforced by physical markers (e.g., heirlooms). A P Culturally defined, appropriate aesthetics guide and support use. A H Scale of furniture close related (or not) to current occupant (e.g., ergonomics).

Thermal comfort is perceived experience of heat influences by physical and cognitive factors. Thermal comfort alters occupants' perception of health and wellbeing. Thermal comfort is influenced by behavior and activity level, occupant dress, HVAC, climate and season, solar access, and air flow.

Thermal comfort is perceived experience of heat influenced by physical, cognitive, and cultural factors (Nicol & Roaf, 2017; Ormandy & Ezratty, 2012).

> **Thermal comfort expectations derive from heritage, time, and place, as well as activity level, occupant dress, climate and season, solar access, and air flow** (Arsad et al., 2023; Schweiker et al., 2018; Frederick-Rothwell, 2017; Djongyang et al., 2010). Individuals react by opening windows, adjusting a thermostat, or modifying behavior.
>
> **Overheating has negative metabolic, cardiovascular, and respiratory health outcomes for older and marginalized individuals** (Hampo et al., 2024; Liu et al., 2024).

Overcooling is associated with sick building syndrome (e.g., indoor air quality, growth of molds and mildews), asthma, and increased blood pressure (Liu et al., 2024).

Temperature fluctuation can worsen symptoms of existing disease, specifically for older individuals.

Regular variation in temperature promotes stronger body metabolism, which decreases incidences of metabolic diseases and increases immune response (van Marken Lichtenbelt et al., 2017).

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Gas-burning furnace Electric heat pump Wood-burning fireplace Solar exposure Window operability Thermal insulation and air seal Occupant CLO and activity level Furniture placement and air circulation	Fireplace as décor / historic remnant	Temperature / humidity control prevents IAQ / mold growth Solar gains Replanting tree-scape Eliminating building-based combustion Building science of insulation and water	Seeking to live with ecological awareness How to use fireplace	Fireplace envy Sweater + slippers Changing behavior	A R Accept variable comfort ranges across rooms, time of day, and season *Adopting behavior and dress to achieve thermal comfort.* R Replanting tree-scape to control solar exposure A H Select new mechanical systems to balance heritage, health, and sustainability goals. *Considering health, building construction, economy, and ecology.* P R Occupy space with awareness of solar exposure, seasons, air flow, and comfort

Lighting is a combination of sunlight, daylight, and electric light sources. These sources provide task, ambient, and accent lighting to modify the physical environment and enable specific actions. Lighting is modified by fixture, shade, controls, material surfaces, and placement.

Daylight depends on solar orientation and spatial layout. Window apertures (including head height and percentage of the exterior wall) affect how much daylight and thermal energy enter a building.

Lighting conditions are also affected by fixtures, shading, controls, placement, and the material reflectance of surfaces.

> **Buildings designed to support daylighting through windows and skylights reduce negative health indicators (e.g., depression, blood pressure, headaches, obesity) and improve vision and sleep quality** (Boyce, 2022; Kaur et al., 2022; Daugaard et al., 2019; Zadeh et al., 2014; Aries et al., 2015).
>
> **Daylight exposure positively affects circadian rhythms, sleep cycles, alertness, mood, and body temperature** (Konis & Schneider, 2018; Aries et al., 2015; Das, 2015).
>
> **Glare and overstimulation from light negatively affect eyestrain, stress, and performance** (Osterhaus et al., 2015).
>
> **Some levels of light countereffect mental health (including mood and memory loss), reduce disease spread (bio-irradiation), and increase self-perceptions of health** (Fahimipour et al., 2018; Elzeyadi, 2011).
>
> **Adequate light for work tasks promotes efficiency and safety** (McKee & Hedge, 2022; Elzeyadi, 2012).

Researchers have not identified an optimum level of daylight exposure but recognize the physiological and cognitive effects of low or excessive exposure.

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Variable daylight by orientation as a result of spatial layout Limited overhead lighting fixtures; Existing lighting fixtures are not original Variable material reflection	No original lighting fixtures	LED technology Efficient day lighting (window lens / glow) Replanting of tree-scape	Limited energy use	Warm light color Use of task lighting Control-able layered lighting strategy Electric lighting is not historically accurate.	A H P Window treatments, wall art, and sunlight produce variety across day and seasons. *Install additional task lighting for evening and detailed work to avoid eye strain.* A P Abundant daylight and circadian cycles guide living patterns. A R Electric lighting is unrelated to history and character of this interior. A R Future decisions about materiality, tree-scape, and spatial use are interdependent on electric lighting.

Indoor air quality (IAQ) affects occupants' health. IAQ is influenced by behavior, maintenance, material finish, HVAC, climate and season, and construction. Indoor air temperature and humidity, as well as the presence of biological matter, affects growth of IAQ contaminants.

Behavior, maintenance, material finish, HVAC, climate and season, and construction influence IAQ measures. Indoor air temperature and humidity affect growth of biological IAQ contaminants.

> Taylor and Filippelli (2022) estimate **one-third of problematic indoor particulates (dust, pathogens, noxious chemicals) are brought into the interior on shoes worn by people.**
>
> **Combustion fumes (wood, coal, or gas) and cooking aerosols create dangerous IAQ contaminants, increasing asthma and other respiratory disease** (Kashtan et al., 2024; Mendy et al., 2020).

Particulate air pollution is also associated with neurological damage, psychiatric disorders, and mental health issues (Liu et al., 2022; Li et al., 2022; Shi et al., 2020; Khan et al., 2019; Shin et al., 2018).

Acute particulate exposure reduces cognitive function (Laurant et al., 2021).

The health risks of infectious agents (e.g., tuberculosis, COVID-19) and noxious compounds (e.g., radon, carbon monoxide) are well known.

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Oak flooring (unsealed) Vinyl flooring Partially repainted interior Forced air HVAC Unvented gas cooking stove Radon removal system / unfinished based and crawl space	Encapsulation of lead-based paint	Material decay Centralized electrostatic and free-standing HEPA filtration	(Potential for) Operable windows and cross ventilation	Limited soft surfaces Dust and spore accumulation Scheduled robotic vacuuming Ventilation limited by window condition (e.g., painted closed)	A R Existing materials are stable unless disturbed or altered. *Ensure repair and renovation work addresses materiality and safety.* A H Regular cleaning and maintenance is required. A H 100+ years of dust and detritus has accumulated in building cavities requiring air filtration. A R If operable, large double-hung windows provide ample cross-ventilation. *Restore operability of windows and screens.*

Microbiomes are the mixture of microscopic bacteria, fungi, and viruses living in a space. Emerging science indicates microbiomes affect concentration, stress levels, and health (Hoisington et al. 2015; Fahimipour et al. 2018). Microbiomes are affected by temperature, air flow, solar access, biological matter, cleaning, and use patterns.

Microbiomes are highly specialized, in that the microbiomes of two adjacent rooms vary considerably based on form and materiality, temperature, air flow, solar access, biological matter, cleaning, and use patterns (Adams et al., 2016; Miletto & Lindow, 2015; Prussin et al., 2015; Adams et al., 2014; Kembel et al., 2014). Individuals and pets shed skin cells, bacteria, and other components of microbiomes continuously, which combine with IAQ particulates (Shan et al., 2019). Human touch points, physical movement through the air, and normal respiration support, mix, and increase the interior microbiome (Cao et al., 2021; Adams et al,. 2015).

Microbiomes positively and negatively affect human health (National Academies of Sciences, Engineering, and Medicine, 2017).

The diversity of microbiomes humans experience relates to healthy immune system responses, lower blood pressure, gut health, and protection from respiratory disease (Robinson & Breed, 2023; Fu et al., 2019; Shan et al., 2019; Leung & Lee, 2016).

Microbiomes may also affect stress, cognitive processing, mental health, and health inequities (Palacios-García et al., 2022; Robinson et al., 2022; Hoisington et al., 2015; Fahimipour et al., 2018).

Mechanical HVAC systems, contemporary building construction, and hygiene concentrate human biomes such that they no longer mimic nature (National Academies, 2017).

Cleaning behaviors actively disrupt and control interior microbiomes resulting in antibiotic resistance (Ben Maamar et al., 2020; Hu & Hartmann, 2020; Velazquez et al., 2019; NESCent Working Group, 2015).

Future interdisciplinary research needs to confirm how humanity produces positive health outcomes through microbiomes (Horve et al., 2020).

Differences in construction, air handling, solar exposure, and use patterns between historic spaces and newly constructed spaces suggests their microbiomes will be distinctive. Since researchers have not yet compared older or historic interiors with newly constructed similar spaces, direct evidence does not exist.

Based on current research about the influences of microbiomes, **historic spaces with daylighting are more likely to have rich indoor air ecologies (e.g., particulates, microbiology).**

The relatively greater air exchange rate with historic buildings should also result in interior microbiomes that are closer to naturally occurring compositions than sealed interior spaces with limited interior-exterior interaction (NESCent Working Group, 2015).

Naturally occurring microbiomes that have co-evolved with humans are likely to promote positive human health outcomes.

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HVAC systems control air circulation and temperature range Limited humidity control Cleanliness Solar exposure Use patterns (e.g., cooking, waste removal) Spatial layout	Maintenance and cleanliness Relatively unsealed building envelope	Tree-scape Dehumidifying Air filtration Variable air flow speed		Daylight and window treatments Cooking, bathing, and venting	A P HVAC system replaced to accommodate advanced air filtration, variable air speed, etc. H P Control relative humidity and particulates via venting and dehumidification. *Additional energy costs for air handling* A H Allergens induce occasional discomfort, health concerns, and diminished use / focus. A H Additional changes to base building required to control biome.

Materiality encompasses the range of materials used to construct and occupy interior spaces. Materials will included surface finishes, structural elements, furnishings, and systems. Maintenance requirements, durability and life cycle, and aesthetics are often interconnected to materiality.

Materiality interacts with maintenance requirements, durability and life cycle, and aesthetics, as well as material performance (e.g., light and sound reflectance) and indoor air quality.

Some construction materials and techniques—like lead, asbestos, arsenic, tar and creosote, preservatives, and other materials—are health hazards (Phillips, 2023; Blando & Lefkowitz, 2013; Cooksey, 2012; American Healthy Home Survey, 2010; Vermont Housing & Conservation Board, 2004; Markel, 2016).

Historic buildings systems may have dangerous unseen conditions (e.g., lead water pipes, aged electrical systems).

Historic material culture items often contain hazardous heavy metals in pigments or core materials (US FDA, 2018 & 1991; Cooksey, 2012; Hughes et al., 2011; Drake & Hazelwood, 2005).

Historic floors may not meet contemporary slip resistance guidance due to wear, finish, or unevenness.

Some contemporary materials contain chemicals with known and emerging health risks (e.g., formaldehyde, flame retardants, plasticizers, antimicrobial chemicals) (Gao et al., 2023; Heisterkamp et al., 2023; Hu & Hartmann, 2020; Shin et al., 2020; Davis et al., 2019).

Materials that construct our environments also have inherent benefits. Materials and finishes may be innately antimicrobial (e.g., linoleum, unsealed wood) (Gonçalves et al., 2016; Mhuireach et al., 2021). **Historic finishes may be stable (e.g., completed off-gassing) and neutral to present-day IAQ concerns.**

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FOCUS	TANGIBLE HERITAGE	INFLUENCES & SUPPORTS	INTANGIBLE HERITAGE	HUMAN IMPLICATIONS	CONSEQUENCES & RESPONSIBILITIES
Health + Interior: Identity	*Landscape • Building • Material Culture • Ephemeral Object*	*Nature • Capital • Technology • Labor • Flora & Fauna • Material • Energy • Air • Water • Nutrients*	*Belief • Knowledge • Organization • Social Capital • Practice • Identity*	*Individuals & Communities • Entanglement • Values • Things • Experience • Action*	*Protection • Reflection • Harm • Adaptation*
Limestone foundation Wood, linoleum, and vinyl flooring Plaster wall and ceiling surfaces Painted and stained surfaces (including encapsulated lead-based paint) Suspected asbestos tape PVC, PEX, and copper water and sewer piping	Largely intact material finishes Most systems (e.g., plumbing, electrical, part of HVAC have been replaced over time) Unknown hidden materials	Replacement / care costs New technologies and new systems increase efficiency / alter function. Sustainability and embodied carbon		Authenticity of historic finishes / appearance Care in handling dangerous materials Integrity / finish of original materials	P R Historic fabric reflects ideals, aspirations, and identity. A H Renovation and changes requires additional protection (e.g., lead, asbestos). P Stable materials have limited health risks (e.g., off-gassing, decay). A H Costs of in-kind replacement and repair require trade-offs. A H Unknown material issues may risk health, cost, or stability.

Maintenance of spaces is directly related to materiality, behavior and use, indoor air quality, and spatial microbiome.

Cleaning products and methods may present health challenges on their own or as a result of how they affect materials in the space (Hu & Hartmann, 2020; Velazquez et al., 2019).

Cleaning and hygience practices affect IAQ, microbiomes, material stability, and other factors.

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Wood, linoleum, and vinyl flooring Plaster and gypsum walls Encapsulated lead-based paint Centralized electrostatic air filtration Air exchange / exhaust Cleaning product selection	Original and restored materiality and finish surfaces Age of equipment and finishes Avoiding surface abrasion	Repair rather than replace Historic surfaces are easily cleaned / vacuumed. Ecological cleaning products		Personal heritage (heirlooms, tchotchkes, and wall art) increases cleaning needs. Scheduled robotic vacuum	P R Low-impact cleaning strategies reduce exposure to chemicals. *Selecting cleaning products and methods to avoid damage to finishes and materials.* P R Historic materiality reduces types of cleaning activities. A R Repair and replacement may require additional cost and effort. A H Materiality may affect health if improperly cleaned or maintained.

Acoustics may affect occupants' concentration, stress level, and rest.
Acoustics describes the production and spread (or blockage) of sound waves. High concentrations of sound may cause physiological harm. Unwanted sound (noise) may increase stress or disrupt sleep cycles.

> **Sound levels may cause direct and indirect physiological harm** (Cormier et al., 2024; Kelly & Lubetzky, 2024; Cacace & Berri, 2023; Yankoty et al., 2022).
>
> **Unwanted sound (noise) increases stress, decreases focus, and disrupts sleep cycles** (Mealings & Buchholz, 2024; Mealings et al., 2024; Casla-Herguedas et al., 2023; Mewomo et al., 2023; Jahncke et al., 2016; Mak & Lui, 2012).

The acoustics of older buildings differ from new construction due to spatial layout, materials, and construction techniques.

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Plaster and wood lathe construction Hard wood flooring Traditional divided floor plan (but with many doors) No wall insulation Variable speed HVAC / air handler	Sound reflection Limited HVAC sound	Physically near neighbors Thermal expansion / contraction Acoustically livelier than new construction STC plaster walls = 52 STC gypsum board walls = 35	Historic expectations / perceptions of privacy	Limited interior sound generation Limited soft furnishings or wall art	P Low sound levels do not increase stress or cause harm (variable). R Minimal acoustic concerns from interior sound reflection / transmission. H R Limited control of exterior sound (lack of insulation)

CONCLUSIONS & DISCUSSION

PROTECT	HURT	REFLECT	ADAPT
How does this interior PROTECT me?	How does this interior HURT me?	How does this interior REFLECT me?	How must I ADAPT to this interior?
19 **consequences or responsibilities PROTECT occupants.**	**18** **consequences or responsibilities HURT occupants.**	**11** **consequences or responsibilities REFLECT occupants.**	**24** **consequences or responsibilities require occupants to ADAPT.**

Heritage aspects of the built interior environment have POSITIVE and NEGATIVE implications for human health.

The single case is limited and not generalizable, but offers guidance for further exploration.

- The worldview of users will substantially influence perceptions of heritage and health (e.g., willingness to adapt to existing conditions).
- Heritage, space, and individual health measures will be highly variable, so conclusions will require individualized and broad consideration of health outcomes.
- The balancing of protection, harm, reflection, and adaptation will not be basic math. The consequences of outcomes may be amplified or complicated by the interrelationships inherent in systems.
- Heritage professionals and designers have obligations to use information responsibly (e.g., causation; avoid reductionist explanations).
- Rigorous scholarship is required to further explore the precise and measurable ways heritage and health may interact.

IMAGE: View across living room and dining room with kitchen doorway visible in the distance (Orthel, 2022).

Interior environments embody personal identity and social position. Interiors also promote health, safety, wellbeing, and **ecological support for human living.**

System models reveal structural relationships that may be otherwise obscured. The outcomes from any one part of the system are not uniquely surprising or significant. The layered results—emphasizing unsuspecting or interconnected recommendations—change heritage practice.

Heritage professionals and advocates should ask new questions about the health characteristics of historic buildings and heritage.

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HEALTHY, HISTORIC BUILDINGS

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