

References (database v4.2, 04.06.2024)

References for the thermal, physical, and dielectric properties listed in our material properties database. Values for tissues of which the properties are not available in the literature are substituted with values from other tissues. In these cases, the tissue used for the value is listed instead of a reference. The rationale for each individual substitution is provided in the Rationale for Tissue Substitutions.

| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|-------------------|--|---|---|--------------------------------------|
| Adrenal Gland | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Bernardi et al., 2003 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Peyman et al., 2012 |
| Air | Bernardi et al., 2003 Collins et al., 2004 See Fluid Properties Database, Equation | Bernardi et al., 2003 Collins et al., 2004 See Fluid Properties Database, Equation | Not in Database | Gabriel et al., 1996 |
| Bile | Bernardi et al., 2003 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Blood | Bernardi et al., 2003 McIntosh and Anderson, 2010 | Collins et al., 2004 Duck, 1990 Holmes Appendix A-B McIntosh and Anderson, 2010 Van Den Berg et al., 1983 | Collins et al., 2004 | Gabriel et al., 1996 |
| Blood Plasma | Duck, 1990 | Duck, 1990 | Not in Database | Not in Database |
| Blood Serum | Not in Database | Not in Database | Not in Database | Not in Database |
| Blood Vessel Wall | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Williams et al., 1988 | Gabriel et al., 1996 |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|----------------------|---|---|---|--------------------------------------|
| Bone | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) |
| Bone (Cancellous) | Collins et al., 2004 McIntosh and Anderson, 2010 | Clattenburg et al., 1975 Collins et al., 2004 McIntosh and Anderson, 2010 | Collins et al., 2004 McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Bone (Cortical) | Duck, 1990 McIntosh and Anderson, 2010 Van Leeuwen et al., 1999 | Collins et al., 2004 McIntosh and Anderson, 2010 | Collins et al., 2004 | Gabriel et al., 1996 |
| Bone Marrow (Red) | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Bone Marrow (Yellow) | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Brain | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Cerebellum |
| Brain (Grey Matter) | McIntosh and Anderson, 2010 Bernardi et al., 2003 Duck, 1990 | McIntosh and Anderson, 2010 | Collins et al., 2004 McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Brain (White Matter) | McIntosh and Anderson, 2010 Duck, 1990 Bernardi et al., 2003 | McIntosh and Anderson, 2010 | Collins et al., 2004 McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Breast Fat | Fat | Hamilton, 1998 | Delille et al., 2002 | Gabriel et al., 1996 |
| Breast Gland | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Thyroid Gland |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|----------------------|--|---|---|--------------------------------------|
| Bronchi | Blood Vessel Wall | Blood Vessel Wall | Parsons et al., 1985 Wu et al., 1985 | Trachea |
| Bronchi lumen | Air | Air | None | Air |
| Cartilage | McIntosh and Anderson, 2010 Bernardi et al., 2003 | McIntosh and Anderson, 2010 Bernardi et al., 2003 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Cerebellum | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Cerebrospinal Fluid | Bernardi et al., 2003 Van Leeuwen et al., 1999 | Collins et al., 2004 Van Leeuwen et al., 1999 Bernardi et al., 2003 | None | Gabriel et al., 1996 |
| Cervix | Uterus | Uterus | N/A | Gabriel et al., 1996 |
| Commissura Anterior | Brain (White Matter) | Brain (White Matter) | Brain (White Matter) | Brain (White Matter) |
| Commissura Posterior | Brain (White Matter) | Brain (White Matter) | Brain (White Matter) | Brain (White Matter) |
| Connective Tissue | Tendon/Ligament and Bone (Cortical) | Tendon/Ligament and Bone (Cortical) | N/A | Tendon\Ligament |
| Diaphragm | Muscle | Muscle | Guenette et al., 1985 | Muscle |
| Ductus Deferens | Blood Vessle Wall | Blood Vessle Wall | Ureter/Urethra | Blood Vessel Wall |
| Dura | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Epididymis | Testis | Testis | Testis | Testis |
| Esophagus | McIntosh et al., 2010 | Collins et al., 2004 | Barnes et al., 1983 | Stomach |
| Esophagus Lumen | Air | Air | None | Air |
| Extracellular Fluids | Duck, 1990 | Duck, 1990 | None | Cerebrospinal Fluid |
| Eye (Aqueous Humor) | Scott, 1998 | Duck, 1990 | None | Cerebrospinal Fluid |
| Eye (Choroid) | Blood | Blood | Xuan et al., 1999 | Blood |
| Eye (Ciliary Body) | Muscle | Muscle | Xuan et al., 1999 | Muscle |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|---------------------------|--|--|--|---|
| Eye (Cornea) | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Bernardi et al., 2003 | None | Gabriel et al., 1996 |
| Eye (Iris) | Muscle | Muscle | Caprioli et al., 1984 Xuan et al., 1999 Werkmeister et al., 2015 | Muscle |
| Eye (Lens) | McIntosh and Anderson, 2010 Bernardi et al., 2003 Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Oezen et al. Bernardi et al., 2003 | None | Gabriel et al., 1996 |
| Eye (Retina) | Brain (Grey Matter) | Brain (Grey Matter) | Caprioli et al., 1984 Xuan et al., 1999 | Brain (Grey Matter) |
| Eye (Sclera) | Bernardi et al., 2003 | Bernardi et al., 2003 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Eye Lens (Cortex) | Eye(Lens) | Eye(Lens) | None | Gabriel et al., 1996 |
| Eye Lens (Nucleus) | Eye(Lens) | Eye(Lens) | None | Gabriel et al., 1996 |
| Fat | McIntosh and Anderson, 2010 Van Den Berg et al., 1983 Collins et al., 2004 Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Duck, 1990 Holmes Appendix A-B Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Fat (Average Infiltrated) |
| Fat (Average Infiltrated) | Fat | Fat | Fat | Gabriel et al., 1996 |
| Fat (Not Infiltrated) | Fat | Fat | None | Gabriel et al., 1996 |
| Gallbladder | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Glandula Vesiculosa | Prostate | Prostate | Prostate | Testis |
| Heart Lumen | Blood | Blood | Blood | Blood |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|-----------------------|--|--|--|-----------------------|
| Heart Muscle | Duck, 1990 McIntosh and Anderson, 2010 | Duck, 1990 McIntosh and Anderson, 2010 Van Den Berg et al., 1983 Bowman et al., 1975 Holmes Appendix A-B | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Hypophysis | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Thyroid Gland |
| Hypothalamus | Brain (Grey Matter) | Brain (Grey Matter) | Brain (Grey Matter) | Brain (Grey Matter) |
| Intervertebral Disc | Cartilage | Cartilage | Cartilage | Peyman et al., 2010 |
| Kidney | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Kidney (Cortex) | Holmes et al., 1983 | Hamilton, 1998 McIntosh and Anderson, 2010 | De Bazelaire et al., 2005 Holmes Appendix A-B Roberts et al., 1995 | Kidney |
| Kidney (Medulla) | N/A | Bernardi et al., 2003 | Holmes Appendix A-B Roberts et al., 1995 | Kidney |
| Large Intestine | McIntosh and Anderson, 2010 Bernardi et al., 2003 | McIntosh and Anderson, 2010 Bernardi et al., 2003 Duck, 1990 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Large Intestine Lumen | Muscle and Water | Muscle and Water | None | Muscle |
| Larynx | Cartilage | Cartilage | Cartilage | Cartilage |
| Liver | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Bowman et al., 1975 Duck, 1990 Holmes Appendix A-B | Williams and Leggett, 1986 McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Lung | McIntosh and Anderson, 2010 | Duck, 1990 McIntosh and Anderson, 2010 | Williams and Leggett, 1986 | Lung (Inflated) |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|-------------------|--|--|--|--------------------------------------|
| Lung (Deflated) | Lung | Lung | Lung | Gabriel et al., 1996 |
| Lung (Inflated) | Lung | Lung | Lung | Gabriel et al., 1996 |
| Lymph | Not in Database | Not in Database | Not in Database | Not in Database |
| Lymphnode | McIntosh and Anderson, 2010 Van Den Berg et al., 1983 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Peyman et al., 2012 |
| Mandible | Bone (Cortical) | Bone (Cortical) | N/A | Bone (Cortical) |
| Medulla Oblongata | Brain | Brain | Brain | Cerebellum |
| Meniscus | Cartilage | Cartilage | Cartilage | Cartilage |
| Midbrain | Brain | Brain | Brain | Cerebellum |
| Mucous Membrane | Collins et al., 2004 | Collins et al., 2004 | McIntosh and Anderson, 2010 | Muscle |
| Muscle | McIntosh and Anderson, 2010 Van Den Berg et al., 1983 Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Duck, 1990 Collins et al., 2004 Bowman et al., 1975 Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Sekins et al., 1980 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Nerve | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Ovary | Testis | Testis | N/A | Gabriel et al., 1996 |
| Pancreas | McIntosh et al., 2010 | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Thyroid Gland |
| Patella | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) |
| Penis | Blood Vessel Wall | Blood Vessel Wall | Joeng et al., 2002 | Blood Vessel Wall |
| Pharynx | Air | Air | None | Air |
| Pineal Body | Hypophysis | Hypophysis | Hypophysis | Thyroid gland |
| Placenta | Hand et al., 2010 | N/A | Duncan et al., 1998 Wagner et al., 1980 | Blood |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|------------------------|--|---|---|--|
| Pons | Brain | McIntosh and Anderson, 2010 | Brain | Cerebellum |
| Prostate | Giering et al., 1995 | N/A | N/A | Testis |
| Salivary Gland | Prostate | Prostate | Bisdas et al., 2007 Williams and Leggett, 1986 | Peyman et al., 2012 |
| SAT (Subcutaneous Fat) | Fat | Fat | Fat | Fat (Average Infiltrated) |
| Scalp | Skin | Skin | Skin | Skin |
| Skin | McIntosh and Anderson, 2010 Collins et al., 2004 Bernardi et al., 2003 Van Leeuwen et al., 1999 | McIntosh and Anderson, 2010 Duck, 1990 Collins et al., 2004 Bowman et al., 1975 Holmes Appendix A-B Van Leeuwen et al., 1999 | Collins et al., 2004 McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 (Skin Dry) |
| Skull | Bone | Bone | Bone | Bone |
| Skull (Cancellous) | Bone (Cancellous) | Bone (Cancellous) | Bone (Cancellous) | Bone (Cancellous) |
| Skull (Cortical) | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) |
| Small Intestine | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Small Intestine Lumen | Muscle and Water | Muscle and Water | None | Muscle |
| Spinal Cord | Brain | Brain | McIntosh and Anderson, 2010 | Nerve |
| Spleen | McIntosh and Anderson, 2010 | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Stomach | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Stomach Lumen | Muscle and Water | Muscle and Water | None | Muscle |
| Tendon\Ligament | McIntosh and Anderson, 2010 Collins et al., 2004 | McIntosh and Anderson, 2010 Collins et al., 2004 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |

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| Tissue | Heat Capacity | Thermal Conductivity | Heat Transfer Rate | Dielectric Properties |
|----------------------|---|--|---|--------------------------------------|
| Testis | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | Gabriel et al., 1996 |
| Testis | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Thalamus | Brain (Grey Matter) | McIntosh et al., 2010 | N/A | Brain (Grey Matter) |
| Thymus | Lymphnode and Fat | Lymphnode and Fat | Lymphnode and Fat | Gabriel et al., 1996 |
| Thyroid Gland | McIntosh and Anderson, 2010 | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Tongue | Muscle | Muscle | Nakase et al., 2004 | Gabriel et al., 1996 |
| Tooth | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | None | Bone (Cortical) |
| Tooth (Dentine) | Duck, 1990 McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | None | Bone (Cortical) |
| Tooth (Enamel) | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 | None | Bone (Cortical) |
| Trachea | Cartilage | Cartilage | Cartilage | Gabriel et al., 1996 |
| Trachea Lumen | Air | Air | None | Air |
| Ureter\Urethra | Blood Vessel Wall | Blood Vessel Wall | John et al., 2002 | Blood Vessel Wall |
| Urinary Bladder Wall | Bernardi et al., 2003 McIntosh and Anderson, 2010 Van Den Berg et al., 1983 | Bernardi et al., 2003 Bowman et al., 1975 McIntosh and Anderson, 2010 Van Den Berg et al., 1983 | Williams and Leggett, 1986 | Gabriel et al., 1996 |
| Urine | Water | McIntosh and Anderson, 2010 | None | Peyman et al., 2012 |
| Uterus | McIntosh and Anderson, 2010 | McIntosh and Anderson, 2010 Olsrud et al., 1998 | N/A | Gabriel et al., 1996 |
| Vagina | Large Intestine | Large Intestine | Wagner et al., 1980 | Large Intestine |
| Vertebrae | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) | Bone (Cortical) |
| Water | Vaxasoftware | Engineering Toolbox Hyperphysics | None | Not in Database |

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