CLAIMS

1. A method of training a tissue classifier for performing quantitative histopathological assessment, comprising:

converting a slide image into a binary slide image, in which the slide image is selected from a library of control images, in which each slide image in the library of control images is associated with a pass classification or a fail classification;

detecting one or more nuclei within the binary slide image;

for each detected nucleus, extracting one or more features from the detected nucleus, in which the features represent a property of the detected nucleus within the binary slide image and in which the one or more features are one or more of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus;

for each binary slide image, generating a combined feature fingerprint from the features extracted for all nuclei in the binary slide image, in which the combined feature fingerprint is a numerical value calculated from processing the features;

incorporating the binary slide image into a cluster, in which the cluster comprises a plurality of images, in which binary slide images with similar combined feature fingerprints are clustered together;

applying a cutoff height to a cluster dendrogram to form a plurality of groups, in which the cutoff height minimizes a number of groups within the plurality of groups based on multivariate analysis of variance of the cluster;

categorizing a first group within the plurality of groups as a positive control group if the first group comprises first slide images associated with the pass classification; and

categorizing a second group within the plurality of groups as a negative control group if the second group comprises second slide images associated with the fail classification.

2. A method according to Claim 1, in which the tissue classifier is capable of determining potency or the quality of the tissue for transplantation into a subject.

3. A method according to Claim 2, in which the tissue is thymus tissue.

4. A method according to Claim 3, in which the tissue is allogeneic cultured postnatal thymus tissue-derived product slices for implantation into a human subject.

5. A method according to Claim 4, in which the human subject is suffering from complete DiGeorge syndrome associated with 22q11.2 deletion; coloboma, heart defect, choanal atresia, growth or mental retardation, genital hypoplasia and ear anomalies or deafness syndrome (CHARGE), or athymia associated with forkhead box protein N1 (FOXN1) deficiency.

6. A method according to Claim 2, in which the tissue classifier determines potency or quality of a tissue for transplantation into a subject of an unknown tissue for transplantation by generating combined feature fingerprints of detected nuclei within slide images in a control library and clustering the slide images with similar combined feature fingerprints together.

7. A method according to Claim 6, in which the unknown tissue is thymus tissue.

8. A method according to Claim 7, where the thymus tissue has been subjected to a culturing process in a thymus organ medium for a period of time to partially deplete the thymus tissue of thymocytes.

9. A method according to Claim 8, in which the period of time is up to 21 days.

10. A method according to Claim 8, in which the period of time is from 12 to 21 days.

11. A method according to Claim 8, in which the period of time is from 5 to 9 days.

12. A method according to Claim 8, in which the culturing process preserves the functional architecture of the thymic stroma.

13. The method according to claim 12, in which the thymic stroma comprises thymic epithelial cells and fibroblasts.

14. A method according to Claim 1, in which the tissue is selected from the group consisting of vascular tissue, skin tissue, hepatic tissue, pancreatic tissue, neural tissue, urogenital tissue, gastrointestinal tissue, skeletal tissue including bone and cartilage, adipose tissue, connective tissue including tendons and ligaments, amniotic tissue, chorionic tissue, dura, pericardia, muscle tissue, glandular tissue, facial tissue, ophthalmic tissue.

15. A method according to Claim 1, in which the combined feature fingerprint is generated from measurements comprising numerical values of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus.

16. A method for performing quantitative histopathological assessment of an unclassified slide image of a tissue, comprising:

detecting a hematoxylin channel from the unclassified slide image, in which the hematoxylin channel is associated with a cellular nucleus within the unclassified slide image of a tissue;

extracting one or more features from the detected hematoxylin channel, in which the features represent a property of the nucleus within the binary slide image and in which the one or more features are one or more of an area of the nucleus, a perimeter of the nucleus, an integrated density of the nucleus, and a circularity of the nucleus;

generating for the unclassified slide image a combined feature fingerprint from the features extracted for all nucleic in the unclassified slide image, in which the combined feature fingerprint is a numerical value calculated from processing the features;

co-clustering the combined feature fingerprint with a first group of fingerprints categorized as a positive control group or a second group of fingerprints categorized as a negative control group, in which:

the first group and the second group are formed by applying a cutoff height to a cluster dendrogram, and

the positive control group comprises a first set of slide images associated with a pass classification and the negative control group comprises a second set of slide images associated with a fail classification; and

determining, based on the co-clustering, if the combined feature fingerprint is associated with the pass classification or with the fail classification.

17. A method according to Claim 16, in which the combined feature fingerprint is capable of determining potency or the quality of the tissue for transplantation into a subject.

18. A method according to Claim 17, in which the tissue is thymus tissue.

19. A method according to Claim 18, in which the tissue is allogeneic cultured postnatal thymus tissue-derived product slices for implantation into a human subject.

20. A method according to Claim 19, in which the human subject is suffering from complete DiGeorge syndrome associated with 22q11.2 deletion; coloboma, heart defect, choanal atresia, growth or mental retardation, genital hypoplasia and ear anomalies or deafness syndrome (CHARGE), or athymia associated with forkhead box protein N1 (FOXN1) deficiency.

21. A method according to Claim 17, in which the combined feature fingerprint determines potency or quality of the tissue for transplantation into a subject of an unknown tissue by generating feature fingerprints of detected nuclei within slide images in a control library and clustering the slide images with similar combined feature fingerprints together.

22. A method according to Claim 21, in which the unknown tissue is thymus tissue.

23. A method according to Claim 22, where the thymus tissue has been subjected to a culturing process in a thymus organ medium for a period of time to partially deplete the thymus tissue of thymocytes.

24. A method according to Claim 23, in which the period of time is up to 21 days.

25. A method according to Claim 23, in which the period of time is from 12 to 21 days.

26. A method according to Claim 23, in which the period of time is from 5 to 9 days.

27. A method according to Claim 23, in which the culturing process preserves the functional architecture of the thymic stroma.

28. A method according to Claim 27, in which the thymic stroma comprises thymic epithelial cells and fibroblasts.

29. A method according to Claim 16, in which the tissue is selected from the group consisting of vascular tissue, skin tissue, hepatic tissue, pancreatic tissue, neural tissue, urogenital tissue, gastrointestinal tissue, skeletal tissue including bone and cartilage, adipose

tissue, connective tissue including tendons and ligaments, amniotic tissue, chorionic tissue, dura, pericardia, muscle tissue, glandular tissue, facial tissue, ophthalmic tissue.

30. A method according to Claim 17, in which the combined feature fingerprint is generated from measurements comprising numerical values of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus.

31. A system for classifying objects within digital images of tissue, comprising:

means for converting a slide image into a binary slide image, in which the slide image is selected from a library of control images, in which each slide image in the library of control images is associated with a pass classification or a fail classification;

means for detecting one or more nuclei within the binary slide image;

means for extracting, for each detected nucleus, one or more features, in which the features represent a property of the detected nucleus within the binary slide image and in which the one or more features are one or more of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus;

means for generating for each binary slide image a combined feature fingerprint from the features extracted for all nuclei in the binary slide image, in which the combined feature fingerprint is a numerical value calculated from processing the features;

means for incorporating the binary slide image into a cluster, in which the cluster comprises a plurality of images, in which binary slide images with similar combined feature fingerprints are clustered together;

means for applying a cutoff height to a cluster dendrogram to form a plurality of groups, in which the cutoff height minimizes a number of groups within the plurality of groups based on multivariate analysis of variance of the cluster;

means for categorizing a first group within the plurality of groups as a positive control group if the first group comprises first slide images associated with the pass classification; and

means for categorizing a second group within the plurality of groups as a negative control group if the second group comprises second slide images associated with the fail classification.

32. A system according to Caim 31, in which the system is capable of determining potency or the quality of a tissue for transplantation into a subject.

33. A system according to Claim 32, in which the tissue is thymus tissue.

34. A system according to Claim 33, in which the thymus tissue is allogeneic cultured postnatal thymus tissue-derived product slices for implantation into a human subject.

35. A system according to Claim 34, in which the human subject is suffering from complete DiGeorge syndrome associated with 22q11.2 deletion; coloboma, heart defect, choanal atresia, growth or mental retardation, genital hypoplasia and ear anomalies or deafness syndrome (CHARGE), or athymia associated with forkhead box protein N1 (FOXN1) deficiency.

36. A system according to Claim 31, in which the system classifies potency or quality of a tissue for transplantation into a subject of an unknown tissue by generating a combined feature fingerprint for the detected nuclei within slide images in a control library and clustering the slide images with similar combined feature fingerprints together.

37. A system according to Claim 36, in which the unknown tissue is thymus tissue.

38. A system according to Claim 37, where the thymus tissue has been subjected to a culturing process in a thymus organ medium for a period of time to partially deplete the thymus tissue of thymocytes.

39. A system according to Claim 38, in which the period of time is up to 21 days.

40. A system according to Claim 38, in which the period of time is from 12 to 21 days.

41. A system according to Claim 38, in which the period of time is from 5 to 9 days.

42. A system according to Claim 38, in which the culturing process preserves the functional architecture of the thymic stroma.

43. A system according to Claim 42, in which the thymic stroma comprises thymic epithelial cells and fibroblasts.

44. A system according to Claim 31, in which the tissue is selected from the group consisting of vascular tissue, skin tissue, hepatic tissue, pancreatic tissue, neural tissue, urogenital tissue, gastrointestinal tissue, skeletal tissue including bone and cartilage, adipose tissue, connective tissue including tendons and ligaments, amniotic tissue, chorionic tissue, dura, pericardia, muscle tissue, glandular tissue, facial tissue, ophthalmic tissue.

45. A system according to Claim 36, in which the combined feature fingerprint is generated from measurements comprising numerical values of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus.

46. A classifier, comprising:

means for detecting a hematoxylin channel from the unclassified slide image, in which the hematoxylin channel is associated with a cellular nucleus within the unclassified slide image of a tissue;

means for extracting one or more features from the detected hematoxylin channel, in which the features represent a property of the nucleus within the binary slide image and in which the one or more features are one or more of an area of the nucleus, a perimeter of the nucleus, an integrated density of the nucleus, and a circularity of the nucleus;

means for generating for each unclassified slide image a combined feature fingerprint, in which the combined feature fingerprint is a numerical value calculated from processing the features;

means for co-clustering the combined feature fingerprint with a first group of fingerprints categorized as a positive control group and a second group of fingerprints categorized as a negative control group, in which:

the first group and the second group are formed by applying a cutoff height to a cluster dendrogram, and

the positive control group comprises a first set of slide images associated with a pass classification and the negative control group comprises a second set of slide images associated with a fail classification; and

means for determining, based on the co-clustering, if the combined feature fingerprint is associated with the pass classification or with the fail classification.

47. A classifier according to Claim 46, in which the system is capable of determining potency or the quality of a tissue for transplantation into a subject.

48. A classifier according to Claim 47, in which the tissue is thymus tissue.

49. A classifier according to Claim 48, in which the thymus tissue is allogeneic cultured postnatal thymus tissue-derived product slices for implantation into a human subject.

50. A classifier according to Claim 49, in which the human subject is suffering from complete DiGeorge syndrome associated with 22q11.2 deletion; coloboma, heart defect, choanal atresia, growth or mental retardation, genital hypoplasia and ear anomalies or deafness syndrome (CHARGE), or athymia associated with forkhead box protein N1 (FOXN1) deficiency.

51. A classifier according to Claim 46, in which the system classifies potency of an unknown tissue by generating combined feature fingerprints of detected nuclei within slide images in a control library and clustering the slide images with similar combined feature fingerprints together.

52. A classifier according to Claim 51, in which the unknown tissue is thymus tissue.

53. A classifier according to Claim 52, where the thymus tissue has been subjected to a culturing process in a thymus organ medium for a period of time to partially deplete the thymus tissue of thymocytes.

54. A classifier according to Claim 53, in which the period of time is up to 21 days.

55. A classifier according to Claim 53, in which the period of time is from 12 to 21 days.

56. A classifier according to Claim 53, in which the period of time is from 5 to 9 days.

57. A classifier according to Claim 53, in which the culturing process preserves the functional architecture of the thymic stroma.

58. A classifier according to Claim 57, in which the thymic stroma comprises thymic epithelial cells and fibroblasts.

59. A classifier according to Claim 46, in which the tissue is selected from the group consisting of vascular tissue, skin tissue, hepatic tissue, pancreatic tissue, neural tissue, urogenital tissue, gastrointestinal tissue, skeletal tissue including bone and cartilage, adipose tissue, connective tissue including tendons and ligaments, amniotic tissue, chorionic tissue, dura, pericardia, muscle tissue, glandular tissue, facial tissue, ophthalmic tissue.

60. A classifier according to Claim 46, in which the combined feature fingerprint is generated from measurements comprising numerical values of an area of the detected nucleus, a perimeter of the detected nucleus, an integrated density of the detected nucleus, and a circularity of the detected nucleus.