CLAIMS

1. A device comprising an optical apparatus for monitoring bacterial growth of a drug-dosed liquid biological sample, the device comprising:

a sample container port for receiving a sample container, in use, the sample container having at least one detection chamber for containing the drug-dosed sample; and

the optical apparatus comprising:

a light source configured to emit light along an incident beam axis that, in use, intersects with at least one detection chamber of the sample container, and to illuminate the drug-dosed sample contained within the detection chamber;

a first photodetector configured to receive light scattered by bacteria in the sample;

a light collection arrangement configured to:

collect light exiting the detection chamber that has been scattered in a forward direction by bacteria in the sample, in a range of scattering angles between +/-4 and +/-20 degrees relative to the incident beam axis, and to direct the collected scattered light to the first photodetector; and

prevent non-scattered light travelling parallel to the incident beam axis and exiting the detection chamber from reaching the first photodetector; and

at least one processor configured to:

measure an intensity of the scattered light received by the first photodetector;

determine a corresponding representative amount or concentration of bacteria present in the sample based on the intensity of the scattered light;

repeat the measuring and determining steps at a series of pre-determined intervals to determine changes in the representative amount or concentration of bacteria present in the sample as a function of time; and

determine a corresponding susceptibility of the bacteria in the sample to the respective drug,

in which the light collection arrangement comprises:

(i) a concave elliptical reflector configured to collect and reflect only light in the angular range between +/-4 and +/-20 degrees relative to the incident beam axis towards the first photodetector so that it is received by the first photodetector; or

(ii) a concave elliptical reflector configured to collect and reflect only forward-scattered light in the angular range between +/-4 and +/-20 degrees relative to the incident beam axis towards a condenser, the condenser arranged to receive light reflected by the concave elliptical reflector and to focus the received light onto the first photodetector.

2. A device according to Claim 1, in which the range of scattering angles of collected scattered light is between +4 and +16 degrees and -4 and -16 degrees relative to the incident beam axis.

3. A device according to Claim 1 or 2, in which the light collection arrangement comprises a concave elliptical reflector shaped to reflect the forward-scattered light from the sample to the first photodetector or condenser, and in which the concave elliptical reflector comprises an aperture aligned with the incident beam axis and configured to allow non-scattered light from the detection chamber to pass through the concave elliptical reflector.

4. A device according to Claim 1, 2 or 3, in which the optical apparatus further comprises a second photodetector arranged to receive non-scattered light; optionally in which the second photodetector is positioned on the opposite side of the light collection arrangement to the sample, and aligned with the incident beam axis to receive the non-scattered light.

5. A device according to any preceding claim, comprising a sample container carousel arranged inside the sample container port for engaging a sample container and configured to bring a detection chamber containing at least a portion of the biological sample in the sample container into alignment with the incident beam axis of the light source of the optical apparatus.

6. A device according to Claim 5, which comprises a motor operably coupled to the sample container carousel and configured to rotate the carousel to periodically bring a detection chamber containing at least a portion of the biological sample into and out of alignment with the incident beam axis of the light source.

7. A device according to Claim 5 or 6, in which the sample container carousel is configured to engage a sample container comprising a plurality of detection chambers, and the sample container carousel is configured to rotate so as to bring each of the plurality of detection chambers of the sample container sequentially into and out of alignment with the incident beam axis of the light source.

8. A device according to Claim 5, 6 or 7, in which the sample container carousel comprises one or more openings configured to align with the one or plurality of detection chambers of the sample container when the sample container is correctly engaged with the sample container carousel in use.

9. A device according to any of Claims 5 to 8, in which the sample container carousel includes one or more detectable calibration features for determining the position and/or orientation of the sample container carousel relative to the incident beam axis of the light source.

10. A device according to Claim 9, which comprises a calibration feature reader communicating with a processor of the device, in use, for determining a time interval between detection of a calibration feature by the calibration feature reader and an associated detection chamber coming into alignment with the incident beam axis of the light source.

11. A device according to Claim 10, in which a processor of the optical apparatus:

(i) communicates with the first photodetector to measure the intensity of the scattered light received by the first photodetector during a predetermined time window corresponding to the time period during which a detection chamber of the sample container is in alignment with the incident beam axis of the light source; or

(ii) adjusts the length of the pre-determined intervals based on the detection of the or each calibration feature.

12. A device according to any preceding claim, in which the processor of the optical apparatus is programmed to repeat the steps of measuring an intensity of the scattered light received by the first photodetector and determining a corresponding representative amount or concentration of bacteria present in the sample as a function of time periodically over a time period of: between 20 minutes and 2 hours, between 20 minutes and 1.5 hours, between 20 minutes and 1 hour or between 30 minutes and 1 hour.

13. A device according to any preceding claim, further comprising a temperature control system for controlling the temperature of air inside the device.

14. A device according to Claim 13, comprising at least one heating element and, optionally at least one air flow regulator arranged, in use, to bring warm air into contact with a sample container received inside the sample container port of the device, so as to maintain a biological sample within a detection chamber at a desired temperature.

15. A device according to Claim 13 or 14, comprising a pair of heating elements, each heating element operably associated with a fan to push warmed air towards the sample container port, in use to heat a sample within a detection chamber of a sample container received within the sample container port of the device.

16. A device according to any preceding claim, in which the light source of the optical apparatus is a laser light source, optionally between 620 nm and 780 nm.

17. A device according to any preceding claim, in which the pre-determined intervals correspond to about 0.6 seconds at a rotational speed of 100 rpm.

18. A device according to any preceding claim, in which the processor of the optical apparatus is configured to identify a plurality of periodically occurring peak features in the measured light intensity, and to carry out the measuring and determining steps only between adjacent peak features.

19. A system for monitoring bacterial growth of a drug-dosed liquid biological sample, the system comprising:

the device as defined in any preceding claim; and

a sample container comprising a plurality of detection chambers, each detection chamber configured to contain a drug-dosed liquid biological sample;

in which the system further comprises:

a sample positioning mechanism configured to align each of the plurality of detection chambers in turn with the incident beam axis such that the light source illuminates the drug-dosed liquid biological sample contained within the illuminated detection chamber.

20. A system according to Claim 19 in which the sample positioning mechanism comprises a rotation or carousel mechanism configured to rotate the sample container, so as to sequentially align each of the plurality of detection chambers with the incident beam axis.

21. A system according to Claim 19 or 20, further comprising a support structure arranged to support the optical apparatus, in which the support structure comprises an opening configured to receive a portion of the sample container comprising at least one of the plurality of detection chambers, such that when the portion of the sample container is located within the opening, at least one of the plurality of detection chambers is locatable along the incident beam axis between the light source and the light collection arrangement.

22. A system according to Claim 19, 20 or 21, further comprising a temperature control system configured to maintain the temperature of the liquid biological sample at a temperature between 35° and 37°.

23. A system according to Claim 22, in which the temperature control system comprises a heating arrangement that comprises a heating element arranged to generate heat, and an air circulation system configured to evenly distribute the generated heat across the plurality of detection chambers of the sample container.

24. A system according to Claim 23, in which the air circulation system comprises at least one recirculation duct and an associated fan arranged to drive airflow across the heating element.

25. A method for determining susceptibility of bacteria in a sample to a drug, the method comprising:

containing a drug-dosed liquid biological sample in a detection chamber of a sample container;

illuminating, by a light source, the sample in the detection chamber with light emitted along an incident beam axis that passes through the detection chamber;

collecting, by a light collector, light scattered by interaction with bacteria in the sample, the light being scattered in a forward direction in a range of scattering angles between +/-4 and +/-20 degrees relative to the incident beam axis;

concentrating, by the light collector, the collected scattered light onto a first photodetector, in which the light collector comprises: (i) a concave elliptical reflector configured to collect and reflect only light in the angular range between +/-4 and +/-20 degrees relative to the incident beam axis towards the first photodetector so that it is received by the first photodetector; or (ii) a concave elliptical reflector configured to collect and reflect only forward-scattered light in the angular range between +/-4 and +/-20 degrees relative to the incident beam axis towards a condenser, the condenser arranged to receive light reflected by the concave elliptical reflector and to focus the received light onto the first photodetector;

determining, by a processor an intensity of scattered light collected by the first photodetector, and a corresponding representative amount or concentration of bacteria particles present in the sample;

repeating, by the processor, the determining step at a series of pre-determined intervals;

determining, by the processor, changes in the representative amount or concentration of bacteria particles in the sample as a function of time; and

determining, by the processor, susceptibility of the bacteria in the sample to the drug used to dose the sample based on the determined changes in the representative amount or concentration of bacteria particles in the sample as a function of time,

in which the sample container comprises a plurality of detection chambers, at least two of the plurality of detection chambers containing a sample dosed with a different drug, or with the same drug at different concentrations of drug, and the method comprises:

sequentially locating each of the plurality of detection chambers containing the drug-dosed sample in the light emitted along an incident beam axis;

carrying out each subsequent step of the method in respect of each of the plurality of detection chambers; and

determining the relative susceptibility of the bacteria in the samples to the respective drugs, or to the respective concentrations of the drug, used to dose the samples to identify the most effective drug for use in a therapeutic treatment regime.

26. A method according to Claim 25, comprising:

collecting, by a second photodetector, non-scattered light passing through the or each detection chamber parallel to the incident beam axis; and

comparing an intensity of the non-scattered light collected by the second photodetector with an intensity of the scattered light collected by the first photodetector in respect of the same detection chamber.